BEE AND BEEKEEPING

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PREFACE

Nowadays, there have been tremendous increases in production and scientific studies related to beekeeping due to reasons such as the high demand for bee products, which are a safe and powerful food, and the fact that honey bees provide pollination and increase the productivity and quality of plant products. However, despite all this, we are faced with many different problems that threaten the future of beekeeping and restrict its production. Some of these problems are new diseases, high use of pesticides, climate change and rapid pollution of natural environments.

In addition to bee diseases and pests that have spread all over the world, producing foods that are free from various antibiotics and other contaminants is essential but has become quite difficult. This imposes a very difficult task on beekeepers.

Considering the great importance of bees for the environment and humans, this book is written in terms understandable to different readers. Again, this book includes many topics such as bee diseases, bee behavior, beekeeping products, melissopalynology and sustainable technical beekeeping.

The chapters in the book were written by researchers who are experts on the subject and are presented in a language and simplicity that readers can understand.

This book is aimed at researchers, academics, undergraduate and graduate students, beekeepers, entrepreneurs, and the general public. The chapters in the book answer many of the problems beekeepers face. Great care has been taken to ensure that the chapters written are of high quality.

We thank all chapter authors for their efforts in producing this work.

Editors
Assoc. Prof. Dr. Yaşar ERDOĞAN
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Bayburt, December, 2023

CHAPTER 1

NUTRIENT NEEDS AND FOOD GATHERING ACTIVITIES OF HONEYBEES

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1.INTRODUCTION

The food consumed and digested by the honey bee, which is an insect, must meet the nutritional needs required for its growth and development. Nutrition covers all the biochemical and physiological changes that occur, from the digestion of food substances in the digestive tract, to their delivery to tissues and cells through the blood, to their conversion into energy and tissue elements of the body, and the elimination of wastes from the body. Although the main part of the body where these events take place is the digestive system; Circulatory, excretory and nervous systems, as well as some muscles and glands, also play a role in digestion and metabolism.

Digestion is the process of breaking down the food that is taken into the body through the mouth and passes into the digestive tract into simple elements that can be absorbed into the circulatory system**.** During the digestion process, large sugar molecules in the structure of carbohydrates are broken down into simple sugars and amino acids, which are the building blocks of proteins; Fats are broken down into glycerol and fatty acids. Food items taken into the mouth are carried to the honey stomach by peristaltic movements of the esophagus. The time the digestion process takes varies depending on the bee's physiological state and living conditions. Liquid food can sit in the honey stomach for about an hour. In case of natural swarming, honey can remain in the honey stomach for 4-5 days in bees in swarming clusters and in other cases where the metabolism slows down in aquaculture.

Flower pollen passes quickly into the stomach, usually remaining in the honey stomach for no more than 20 minutes, and digestion and absorption are completed within 24 hours and digestive residues are transferred to the rectum. Pollen grains are very resistant to physical change as they pass through the digestive tract. The shell parts of pollen grains consist of cellulose, pectin and sporopollenin and are generally not digested by bees.

Digestion begins as soon as the pollen reaches the stomach. The stomach contains enzymes and lipase that enable the digestion of proteins. The digestion process proceeds rapidly and most of the nutrients in the pollen grain are removed. Over time, the inside of the pollen grains becomes almost completely empty. The shell part reaches the rectum in an emptied, colorless and shrunken state. Enzyme activity and digestion processes are at the highest level in the proventriculus, and metabolic absorption is at the highest level in the ventriculus.

Enzymes involved in the digestive system are invertase, amylase, glycogen, lipase, protease, pepsin and trypsin. When liquid food is taken, invertase and amylase enzymes begin to affect the food in the forestomach. The invertase enzyme breaks down sucrose, a disaccharide, into monosaccharides. The resulting monosaccharides are absorbed directly into the body without undergoing any further processing in the digestive tract. Starch is broken down first into disaccharides by the action of amylase and then into monosaccharides with the help of other enzymes. Lipase enzyme also acts on lipids to form glycerol and fatty acids. Proteinase, pepsin and trypsin enzymes are involved in the transformation of proteins into peptides. The peptides are then hydrolyzed into amino acids. Glycogenase, on the other hand, converts the glycogen stored in the body into glucose and enables it to be used as a ready energy source. Energy is required not only for the biosynthesis of organic molecules, but also for the movement of muscles, transmission of neural impulses, and a number of other activities.

While digestive residues are stored in the rectum, excess water from the feces is reabsorbed into the body. Rectal glands in the large intestine secrete a secretion containing the catalase enzyme, which prevents the putrefaction (putrid) of the feces. Thus, it is possible for bees to store more feces in their large intestines during long winter periods. The products formed after digestion pass into the blood through the epithelial cells of the stomach tissue and the small intestines, and from there they are transported to different tissues and cells of the body.

Metabolism; It refers to all the changes and metabolic events that the nutrients resulting from the digestion of food undergo, from being absorbed into the circulatory system, to being delivered to the needed tissues and cells of the body through the blood, to being broken down into energy and the removal of wastes from the body. Metabolic residues resulting from these processes are given to the small intestine through excretory organs called Malpighian tubes and are excreted from the body through the anus along with the digestive waste, feces.

As a result of metabolic activities, the potential energy in food is transformed into heat, mechanical and other forms of energy. Metabolism is an important event that distinguishes a living organism from a dead one. Metabolic activities are of great importance for the development of cells in number and size, and especially for the embryonic and post-embryonic development of bees and the egg laying of the queen bee. In adult bees, events that require more energy become important. Because body development is largely completed in adult bees, cell production has decreased significantly.

There is a very close relationship between the speed of metabolic activities and the condition of the colony, the physiological structure of the bees, their age and whether they perform their duties. The indicator of metabolic rate is based on the body's oxygen consumption and the amount of carbon dioxide formed and excreted from the body as a result of metabolic activities. Energy is released through the oxidation of foods. The quality or metabolic values of the foods taken into the body are measured by the caloric value they produce as a result of oxidation in the body. 1 gram of carbohydrate and protein provides 4.1 calories of energy through oxidation; 1 gram of lipid provides 9.3 calories of energy.

1.1. Feding in Honey Bees

Unlike mammals, body temperature in bees depends on the environmental temperature and varies within certain narrow limits. This change is also valid for an isolated single bee. Due to the increase in environmental temperature, body temperature and metabolic rate in bees also increase. Despite large variations in environmental temperature, bees on honeycombs in a bee colony, which is a biological unit, can keep their body temperature at a relatively constant level with certain mechanisms.

For this purpose, the metabolic rate of bees increases at low environmental temperatures and the body temperature is maintained with the additional energy obtained. The same is true at high ambient temperatures. At high environmental temperatures, metabolic activities in bees accelerate again and some of the energy produced is used to reduce the rising ambient temperature in the hive. Due to the increase in metabolic rate, both the body's oxygen consumption and the amount of carbon dioxide formed as a result of metabolic activities increase. These changes in metabolic rate apply not only to individuals but also to the colony as a whole.

In cases where it becomes difficult to find food and the food stock in the hive decreases, for example in early spring, bees try to adapt to these extreme conditions and survive even in adverse environmental conditions by reducing their metabolic rates.

As a result, there is a very close relationship between environmental temperature and the activities of bees. If the environmental temperature drops below 10 °C or rises above 36 °C, bees' activity stops. While bees lose their ability to fly at environmental temperatures around 10 °C; At 7 °C they become completely immobile. The most suitable temperature for the normal activities of bees is between 21-35 °C.

A certain environmental temperature is also required for activities such as infertile queen bees going on mating flights, worker bees working in field services, and drone flights. Activities such as secretion of beeswax by worker bees, honeycombs and brood production can be carried out under optimum and uniform climate and environmental conditions. The fact that bees reduce their brood activities in autumn and stop them completely towards winter is also related to the decrease in air temperature and the change in environmental conditions.

Bees form clusters when the temperature inside the hive drops below 10 °C, and when the temperature inside the cluster rises above 14 °C, this causes the winter cluster to expand. In this way, bees emerge into spring by forming clusters and slowing down their metabolism during the long and low-temperature winter months.

The sugar level in the blood of worker bees is 2% on average. This amount can go up to 4.4% in some cases. When the sugar level in the blood drops below 2%, the bee cannot fly. Although the average blood sugar level of male bees can be up to 1.2%, it is lower than that of worker bees. Blood sugar levels in queen bees vary depending on the physiological state of the queen. Queen bees that are isolated and not accompanied by nurse worker bees cannot maintain their blood sugar levels, even if there is enough honey in their cages. In this respect, queen bees need the care and feeding of worker bees under all circumstances.

The main food source for honey bees is nectar, honey and pollen. Honey is a basic carbohydrate, 95-99% of its dry matter is sugar. Therefore, the main energy source is honey. Honey can be converted into glycogen and fat. Large sugar molecules are broken down into simple sugars. While proteins are broken down into building blocks; Fats are absorbed without any change or by breaking down into glycerol and fatty acids. Thus, small molecules are used as energy sources. Energy beyond the energy requirement is used or stored in the formation of larger molecules and elements. Energy is required not only for the biosynthesis of organic molecules, but also for the movement of muscles, neural impulses and other activities.

Honey bees can survive on a pure carbohydrate diet for long periods of time. However, pollen is essential for the growth of newly hatched young worker bees and the development of their food glands. Bees cannot use pollen as an energy source. Beekeepers know very well that even if there is more than enough bee bread and pollen in the hive, if there is no honey, the colonies will starve to death. On the other hand, if there is no pollen, brood rearing and colony population will decrease, even though honey is present in the hive.

The nutritional needs of honeybees are not limited to just carbohydrates and proteins. In addition to carbohydrates and proteins, bees also need lipids, vitamins, minerals and water to feed. Honey bees get all the nutrients they need from nectar, pollen and water. In technical beekeeping, when bees cannot meet their nutritional needs from natural sources, they are fed with feeds prepared with carbohydrates and proteins.

1.2. Nutrient Needs of Honey Bees

1.2.1. Carbohydrates and Nectar

Honey bees have to consume carbohydrates to provide the energy required for all their vital activities inside and outside the hive. The average blood sugar content of worker bees is 2.0%, of male bees 1.2%, of newly emergenced queens 1.7% and of egg-laying queen bees 0.3%. Ana arıların kan şekeri kapsamı oğul mevsiminde % 1.1'e yükselmektedir. The blood sugar of queen bees kept in cages without worker bees is lower than that of queen bees caged with worker bees. This shows that they cannot keep their blood sugar levels at a constant level without relying on nurse bees.

Flying worker bees consume an average of 10 mg of blood sugar per hour, and drones consume 14 mg of blood sugar during the 30-minute mating flight. Flying drones consume 1 mg of blood sugar for every 15 km distance. In other words, flying male bees need approximately 3 times more sugar per hour than worker bees. A worker bee loses the ability to fly if its blood sugar drops below 1%; but it can still flutter its wings and walk. Sugar consumption of caged bees varies depending on the outdoor temperature. While a bee needs approximately 11 mg of sugar per hour at 11 ºC; It requires 0.7 mg of sugar at 37 ºC and 1.4 mg at 48 ºC. These values show that honey consumption is minimum at 37 ºC. As we move away from this temperature in positive and negative directions, honey consumption increases significantly.

The main carbohydrate source in the natural diet of honey bees is nectar (Figure 1.1). The sugar concentration of nectar varies between 5-75%, but is generally around 25-40%. The main sugars in nectar are sucrose, glucose and fructose. Sucrose is broken down into glucose and fructose by the action of the invertase enzyme. Nectar is converted into honey as a result of some physical and chemical reactions. In addition to all these simple sugars, honey also contains some complex sugars such as raffinose, maltose, isomaltotetrose and isomaltopentose. While honey bees are attracted to some carbohydrates, they are not interested in others at all, even if they are sweet to humans. Bees use glucose, fructose, □-methyl glycoside, maltose, teralose, sucrose and hybridose, and these are sugars perceived as sweet by bees. Some sugars are toxic to bees, the most toxic sugar being mannose. A bee that consumes mannose dies within a few minutes. Galactose, rhamnose, arabinose, xylose, lactose, mellibiose and raffinose sugars are also sugars that have a reducing effect on the lifespan of bees. A medium-sized colony consumes approximately 75 kg of honey per year. The amount of honey consumed in summer is around 45 kg, 22 kg in winter and 8 kg for wax secretion.

Figure 1.1 Nectar is the natural energy source of honey bees.

Nectar is a raw material that bees use to make honey. In plants that need insects for pollination, flower nectar is the nectar secreted by the flowers to attract bees; The sugary digestive residues of insects living on plants and sucking plant sap are called insect nectar (honeydew). Therefore, nectar is the general name for all the resources that bees use to make honey. However, here the general word nectar will be used for flower nectar and insect nectar will be discussed separately.

The raw material or source of nectar is plant sap. Plant sap is generally a colorless, transparent liquid that refracts light. The pH of plant sap, which is a near-neutral and slightly alkaline liquid, is between 7.3-8.6. The amount of dry matter varies between 5-30%. 1-3% of the dry weight is ash. Nearly 90% of the dry matter consists of carbohydrates. The carbohydrate content of plant sap varies depending on the season and the time of secretion. Most of the sugars in its structure consist of sucrose. Apart from sucrose, it also contains monosaccharides, oligosaccharides, sugar phosphates and sugar alcohols, mannitol and sorbitol in varying amounts depending on the plant species.

The sugar content of the nectar they produce is as important for honey bees as the nectar yield of the plants. However, studies show that the sugar content of nectar varies depending on a wide variety of factors. The sugar content in the nectar of some plants is given in Table 1.1.

Table 1.1. Sugar Content in the Nectar of Some Plants.

Plants	Sugar Content in Nectar (%)
Clover (Medicaco sativa L.)	35-60
Wild clover (Lotus graber)	52
Sainfoin (Onobrychis sativa)	55
Willow (Salix spp)	60
Acacia (Robinia pseudoacacia)	63
Linden (Tilia cordata)	34
Sunflower (Helionthus annus)	32
Peach (Persica vulgaris)	16-40
Apricot (Armeniaca vulgaris)	12
Cotton (Gossypium herbaceum)	41
Plum (Prunus domestica)	10-60
Pear (Pyrus communis)	4-30
Orange (Citrus nurantium)	10-30
Sage (Salvia officinalis)	48
Cherry (Cerassus avium)	45-55
Apple (Malus communis)	13
Tobacco (Nicotiana tabaccum)	26
Yellowstone clover (Melilotus officinalis)	35-60
White clover (Trifolium repens L.)	41
Dandelion (Taraxacum officinale)	51

Öder, 1989.

Apart from carbohydrates, plant sap also contains some nitrogenous compounds, oils, organic acids, vitamins and mineral substances, especially glutamic acid, glutamine, aspartic acid and asparagine. Nectar is the raw material that bees take from plants to make honey; The source of nectar is plant sap. Plant sap is called raw nectar until it is secreted from the nectar secretion organs of plants.

Nectar consists of a watery solution of various sugars and contains between 5-75% sugar depending on the plant species and various natural conditions. In addition to sugars, nectar contains small amounts of nitrogenous compounds, minerals, organic acids, vitamins and colorants. The sugars in nectar are mainly sucrose, glucose, fructose and maltose. While the sucrose rate in plant nectar is lower than that of raw nectar; The monosaccharide rate is higher. This shows that sucrose can be partially converted into monosaccharides as a result of enzymic activity in the nectar secretion organs of plants.

The carbohydrate amount and sugar composition of nectar varies depending on various factors. The nectar of some plants also contains some substances that can be harmful to bees and humans. A typical example of this in our country is the nectar of the Black Sea rhododendron (Rhododendron ponticum). Bees that work on the Black Sea rhododendron and get nectar from this plant make poisonous honey. Nectars are examined in three groups according to the sugars they contain.

1. Nectars containing high sucrose content or containing only sucrose (in plants with deep-tubed flowers belonging to the Leguminosa family).
2. Nectars containing little or no sucrose but only glucose and fructose (in Crucifera family and similar open-flowering plants).
3. Nectars with balanced sucrose, glucose and fructose content (in sweet clover).

Honey bees generally prefer plants with balanced sugar content among these three groups of nectar. For this reason, bees prefer sweet clover over hybrid clover, red clover and clover, which have high sucrose content in their nectar.

Nectar is secreted from the nectar secretion organs (nectarium) of plants; Although these organs are generally found in the flowers of plants (intrafloral secretory organs); They can also be found in other parts (secretory organs outside the flower). Inner flower nectar secretion organs are located in the flower axis or in the sepals and petals, depending on the plant species; extrafloral secretory organs are located on the stem or leaves.

1.2.1.1. Factors Affecting the Nectar Yield of Plants

Nectar yield of plants is under the influence of many factors. These are related to vegetative factors such as the number and size of nectar secretion organs carried by the plant, the nature of flowering, pollination and fertilization and the variety of the plant; These are environmental factors related to the environment in which the plant lives, such as sunlight, air temperature, humidity, soil water capacity, soil temperature, ventilation and soil fertility.

Nectar secretion usually begins with flowering, gradually increases depending on development, and continues to decrease until the end of flowering. Pollen develops, matures, and the pistil becomes ready to accept pollen. Then pollination and fertilization occur and a decrease in nectar secretion begins. In other words, there is a clear relationship between the visit of bees and nectar secretion. This is clearly seen in lavender, clover and lion's mouth. The value of a nectar-secreting plant and its attractiveness to bees depends on the flowering period of the plant, the amount of nectar it secretes during this period and the sugar content of the nectar. Just as plant species differ in this respect, varieties of the same species may also differ from each other.

It is generally not possible to separate the effects of factors affecting the nectar yield of plants. Light has a significant effect on the nectar production of plants as it supports photosynthesis, promotes flowering and accelerates growth. For example, a close relationship has been detected between nectar yield and sunlight in clover, some clover species and saint herb. Light radiation increased nectar yield in meadow clover by 300%. Although light is a factor that increases the nectar yield of herbaceous plants; The effect of light on trees and bushes, which provide the sugars necessary for nectar secretion from their body stores, is to reduce nectar secretion.

Plants cannot secrete nectar unless the environmental temperature exceeds a certain limit that will ensure the activity of enzymes effective in nectar secretion. This threshold varies depending on plant species. This is around 18 ºC for linden (Tilia), 8 ºC for bird cherry (*Prunus avium*), 18-20 ºC for berry (*Prunus lauroceracus*) and 17-21 ºC for cucumber (*Cucumis sativa*). The effect of temperature decreases in plants where nectar secretion has started and continues. Days with low temperatures and clear skies at night and sunny and hot days are the days when plants produce more nectar. Insufficient rainfall and increasing temperatures create water stress in plants, reducing nectar secretion. Increasing atmospheric humidity increases nectar production in plants; but it reduces the sugar density of the nectar. Studies on the nectar yield of plants show that low rainfall during flowering periods and high rainfall in other periods creates the most suitable environment for high nectar yield.

The temperature, ventilation and fertility of the soil also affect the nectar production of plants. The decrease in temperature in the roots of the plant reduces the transmission of sugar to the trunk and branches and nectar yield. On the other hand, sandy soils reduce the water retention capacity of the soil during dry periods; However, it increases the nectar production of the plant by providing superiority to heavy soils in terms of ventilation and temperature. Soil fertility, which means that the soil has the necessary nutrients for adequate growth, development and flowering in plants, has an increasing effect on flower formation, flowering time and nectar yield in plants.

1.2.1.2. Nectar Sources

Türkiye is one of the countries with the richest flora in the world. As a matter of fact, it is known that approximately 10,000 plant species grow in our country and approximately 450 plant species that grow naturally or are cultivated are important for beekeeping.

It has been determined that most of these plants with high nectar yield capacity per hectare are widely grown in our country. It is possible to examine the plant species important for beekeeping in three groups: plants that grow spontaneously in nature, cultivated plants, and trees and shrubs (Table 1.2, Table 1.3, Table 1.4).

Plants that grow naturally in nature, such as thyme, sage, stone clover, chicory, honeysuckle, lavender, rock ivy, donkey thistle, wild mustard, mint, pendant, ragweed, viper grass, wild clover and wild sainfoin are important nectar sources with high yield capacity. . On the other hand, cultivated plants such as rapeseed, safflower, carob, clover, sainfoin, vetch, sunflower, cotton, tobacco, meadow clover, red clover, white clover and hybrid clover are important nectar sources. In addition, acacia, linden, maple, citrus, eucalyptus, arbutus, blackberry, willow, various fruit trees and pine species are also known as trees and shrubs that are important as nectar sources.

Table 1.2. Some of the Plants and Nectar Classes that Grow Naturally in Nature and are Important in Beekeeping.

Plants	Nectar Class
Astragalus (Astragalus stevenianus)	3
Rock ivy (Hedera helix)	5
Ballıbaba (Lamium album)	5-6
Thyme (Thymus serpillum)	4
Lavender (Lavandula latifolia)	4
Mint (Mentha arvensis)	5
Pomegranate (Mentha pulegium)	5
Sage (Salvia spp)	4-5
Lemon balm (Melissa officinalis)	2
Fireweed (Epilobium angustifolium)	5-6
Broomrape (Calluna vulgaris)	4
Foxglove (Digitalis purpurea)	5
rue (Ruta montana)	5
Scabby grass (Scabiosa caucasica)	5
Viper weed (Echium vulgare).	6
Comfrey (Syymphytum asperum)	5
Mallow (Malva sylvestris)	2
Sage (Solvia spp)	4-5
Donkey thistle (Echinops orientalis)	4
Milk thistle (Carduus hamulosus)	2
Wild clover (Medicago sativa)	5
Stone clover (Melilotus spp)	4-6
Gazelle horn (Lathyrus corniculatus)	2-4
Thyme (Thymus kotschyanun)	5
Wild mustard (Sinapis arvensis)	4-5
Wild basil (Clinopodium vulgare)	2

Class1: 0-25 kg/ha
2: 26-50 kg/ha
3: 51-100 kg/ha
4: 101-200 kg/ha
5: 201-500 kg/ha
6: more than 500 kg/ha

Table 1.3. Some Cultivated Plants and Nectar Classes Important for Beekeeping.

Plants	Nectar Class
Cotton (Gossypium herbaceum)	1
Sunflower (Heliontus annuus)	2
Safflower (Carthamus tintorius)	4-5
Tobacco (Nicotiana Tabaccum)	2
Meadow clover (Trifolium prantense)	5
Red clover (Trifolium incarnatum)	3-4
White clover (Trifolium repens)	3-4
Hybrid clover (Trifolium hybridum)	4
Common vetch (Vicia sativa)	3
Broad bean (Faba vulgaris)	3
White mustard (Sinapis alba)	1-3
Black mustard (Sinapis nigra)	1-3
Sainfoin (Onobrychis sativa)	3-4
Rapeseed (Brassica rapus)	4-5
Sage (Salvia officinalis)	5
Horse chestnut (Aesculus spp)	4
Blackcurrant (Ribes rubrum)	4
Onion (Allium cepa)	3

Class 1: 0-25 kg/ha
2: 26-50 kg/ha
3: 51-100 kg/ha
4: 101-200 kg/ha
5: 201-500 kg/ha
6: more than 500 kg/ha

Table 1.4. Some Trees and Shrubs and Nectar Classes that are Important as Nectar Sources.

Plants	Nectar Class
False locust (Robinia pseudoacacia)	6
Linden (Tilia rupra subsp.)	6
Orange (Citrus nurantium)	-
Purene (Erlas arborea)	-
heather (Erica spp)	4
Arbutus (Arbutus unede)	-
Carob (Carotonia siligua)	-
Judas tree (Cercis silignastrum)	3
Ash tree (Fraxinus excelsion)	-
Lemon (Citrus limonum)	-
Eucalyptus (Eucalyptus)	-
Sour cherry (Cerasus vulgaris)	2
Hawthorn (Crataegus spp)	2
Quince (Cydonia oblonga)	1
Blackberry (Rubus sanctus)	3
Raspberry (Rubus idaeus)	3
Pear (Pyrus communis)	1
Apricot (Armeniaca vulgaris)	2
Almond (Amygdalus communus)	1
Cherry (Cerasus avium)	2
Plum (Prunus domestica)	2
Chestnut (Castanae sativa)	2
Maple (Acer campestre)	6
Fireweed (Epilobium angustifolium)	5-6
Red pine (Pinus brutia)	5
Larch (Pinus nigra)	5
Scots pine (Pinus sylvestris)	5
Willow (Salix spp)	4

Class 1: 0-25 kg/ha
2: 26-50 kg/ha
3: 51-100 kg/ha
4: 101-200 kg/ha
5: 201-500 kg/ha
6: more than 500 kg/ha

Apart from the nectar sources mentioned above, the nectar of some plants leads to the production of poisonous and bitter honey. Plants that constitute the source of this type of honey can be found almost all over the world. Some of the honey in this group is poisonous and harmful only to humans, and some is poisonous and harmful to both humans and bees. It has been determined that California horse chestnut is poisonous to bees and the toxic effect is due to the pollen, while mountain laurel honey is poisonous only to humans and this effect is due to the alkaloids in its structure.

In our country, tobacco fields, rhododendron in the Black Sea Region, oleander and datura in the south are plants that produce bitter or poisonous honey. Rhododendron is found on the coastline from Hopa to Adapazarı in the Black Sea Region; Datura is especially found in Izmit and Adapazarı regions. Rhododendron pollen also contains andromedotoxin. Datura honey is not as dangerous as honey obtained from rhododendron. The honey of some trees, such as chestnut, is not poisonous but is bitter. People who eat poisonous honey experience vomiting, dizziness, blackout, ear ringing and loss of consciousness. For this reason, beekeeping should not be done in areas where such plants are common unless it is necessary.

1.2.1.3. Insect Nectar (Honeydew)

The part of the sap that some insects with piercing-sucking mouthparts, which live on plants and feed on plant sap, cannot benefit from, and which they store in a section at the end of the digestive system and expel at certain intervals, is called insect nectar. Honey bees collect these types of food items in periods when there is a shortage of flower nectar in nature and use them to meet their energy needs and prepare a substitute food item (honey). Such residues used by bees and popularly known as basura are called insect nectar. The colloquial name for honey made in this way is h basura honey, basra honey or secretion honey.

Insects that suck plant sap and use it as food belong to the order Hemiptera and Homeptera. These insects reach the sap by piercing plant tissue with their piercing-sucking mouthparts. The ingested sap passes through the digestive tract of the insect, and the unusable part is left in small drops on the leaves and shoots of some herbaceous and woody plants. This sugary substance left is taken up by bees or some other insects and evaluated.

Bees make large amounts of honey from basura, which have a completely different structure than nectar in some plants. For this reason, basura have great economic importance. The most well-known and common basura honey in our country is obtained in Western Anatolia and especially in the Muğla region. Every year, thousands of colonies are brought to this region from different parts of the country to obtain basura honey.

The pine weevil (*Monophlebus hellenicus*), which lives by sucking plant sap on pine (*Pinus*) species in Western Anatolia, is the most important source of secretion honey production in our country and this insect has a major place in the honey production of the region. Additionally, in certain sizes, poppy (*Papaver*), thistle (*Carduus*), rose (*Rosa*), linden (*Tilia*), willow (Salix), oak (Quercus), chestnut (Castenea), poplar (*Populus*), birch (*Batula*), tamarisk (*Tamarix*), elm (*Ulmus*), fir (*Abies*), spruce (*Picea*), pine (*Pinus*) and stone fruit (Prunus) species also produce insect secretions.

The distribution area of the pine cotton weevil (*Marchalina hellenica*), which is the most important source of hemorrhoid honey in our country, is limited to Turkey and Greece. In our country, it is seen in a wide area in Büyükada, Heybeliada, İzmir, Denizli, Edremit, Antalya and Muğla regions. This insect lives on red pine, Scots pine and stone pine trees in the mentioned regions (Figure 3.2).

Figure 3.2. Türkiye is the most important habitat of Marchalina hellenica in the world.

Basura are the digestive residue of insects that live by sucking plant sap. Its composition differs significantly from flower nectar. The nitrogen content of hemorrhoids in its dry matter is 0.2-1.8%, and the sugar rate in its dry matter is 90-95%. Carbohydrate content consists of a mixture of different sugars. Some of the sugars in basura are not found in the plant sap. These are synthesized from sugars in plant sap under the action of enzymes found in the insect's salivary glands and other parts of the digestive tract. In other words, while high-molecular carbohydrates are broken down in the insect's digestive system; On the other hand, new sugars are synthesized from simple molecule carbohydrates.

The digestive residues of insects living on some linden species contain galactose, mannose, and mellebiose; This type of insect nectar is harmful to bees. While the pH of flower nectar varies greatly; The pH of the hemorrhoids is between 3.90-4.88. According to the results of the analysis performed on fourteen samples, the composition of hemorrhoids is shown in Table 1.5.

Pine honey obtained from basura is an important export product. 80% of the honey we export is pine honey. The hemorrhoid beetle, which is the source of pine honey, sucks plant sap for nutrition. Plant sap contains 20% protein and 80% carbohydrates. The insect meets the protein required for its development by absorbing large amounts of sap. However, it cannot use all the carbohydrates in its body due to the excess sap it receives, and it excretes the part it does not need with some changes. This digestive residue of the insect is collected by bees and used to meet energy needs and to make pine honey.

Table 1.5. Composition of Insect Nectar.

Contents	Average	S.deviation	Change Range
Water (%)	16.30	1.74	12.20-18.20
Fructose (%)	31.80	4.16	23.91-38.12
Glucose (%)	26.08	3.04	19.23-31.86
Sucrose (%)	0.80	0.22	0.44-1.14
Maltose (%)	8.80	2.51	5.11-12.48
High Sugars (%)	4.70	1.01	1.28-11.50
Unknown Substances (%)	10.10	4.91	2.70-22.40
Ash (%)	0.736	0.271	0.212-1.185
Nitrogen (%)	0.100	0.053	0.047-0.223
Total Acid (meg/kg)	54.88	10.84	34.62-76.49

Doğaroğlu, 1987.

Pine honey is a honey that is dark in color, has a unique smell, has a weak sugaring ability and is sold in foreign markets. However, it is reported by some researchers that it should not be given to bees as winter food due to its mineral salt content and by others due to its high dextrin content. On the other hand, bees may suffer from pollen shortage in pine honey production areas. According to the findings, although this insect is constantly found on pines, it does not cause any harm to the plant other than causing the growth of some fungi on the bark.

1.2.2. Proteins and Pollen

Honey bees use protein mainly for tissue growth and the development of glands and especially food glands. Approximately 13% of newly hatched bees and 15% of the wet weight of 5-day-old bees consist of protein.

Proteins can be transferred from one part of the body to another part where they are needed. This suggests that protein is transferred to these glands during the royal jelly production period when the hypopharyngeal glands are developing. When bees reach older ages, these glands become inactive and this time the proteins are transferred to the flight muscles where they are needed. Some proteins are also stored in body fat for other needs. This shows that the nitrogen content and weight of newly hatched bees are directly affected by the pollen consumption of nurse bees.

The main protein source of honey bees is pollen. Pollen is produced by the male organs found in flowers and is one of male reproduction. It is found in the form of a small package on the male organ of the flower and is the only natural protein source of bees. It has a very important place in the nutrition of bees because it contains high levels of protein in its structure. The shape of pollen varies depending on plant species. By taking advantage of this feature, it is possible to identify the plant species that form the basis for the production of honey by examining the pollen mixed with honey (Figure 1.3).

Figure 1.3. Pollen is the bees' only natural source of protein.

A pollen grain consists of a two-layered shell from outside to inside, a nucleus nest, and two separate nuclei. There are a number of pores on the outer shell, which have different shapes and appearances depending on the plant species. The soft inner shell layer has a smoother appearance. The larger of the seeds is the developer and the other is the generative nucleus, and the joint effect of both ensures seed formation through pollination and subsequent fertilization.

The chemical composition of pollen includes 20-25% water, 1.8-3.7% ash, 13-17% carbohydrates, 3-5% cellulose, 6-28% protein and 1.2-3.7% fat. The free amino acids in its structure are alanine, arginine, aspartic acid, glutamic acid, glycine, histidine, leucine, isoleucine, lysine, methionine, phenylalanine, proline, hydroxyproline, tyrosine and valine.

Although the main importance of pollen in the life of bees is that it is a strong source of protein; apart from proteins, it also contains various carbohydrates, mineral substances, organic acids, fat and fatty acids, nucleic acids, some enzymes, flavonoids, caratonoids, growth regulators, terpenes and various vitamins.

It is estimated that a medium-sized colony collects an average of 20-50 kg of pollen per year. A single bee requires approximately 3.21 mg of nitrogen, equivalent to 145 mg of pollen, before hatching. In other words, developing bees need an average of 120-145 mg of pollen until they emerge from the cell.

It is necessary for bees to feed on pollen in order for their food glands, fatty tissues and other organs to grow and develop. Bees begin to consume pollen approximately 2 hours after emergence from the eye. Maximum pollen consumption occurs when they are 5 days old. Pollen consumption stimulates brood food production, and bees at the age of 5-6 days begin to produce royal jelly. Under normal conditions, pollen consumption decreases when bees are 8-10 days old. Male bees do not eat pollen; but they feed on a mixture of honey, pollen and hypopharyngeal gland secretion. Queen bees are fed with royal jelly throughout their lives.

Pollen grains are very difficult to break apart except by mechanical methods. While some pollen grains are hydrolyzed in the proventriculus; Some undergo enzymic activity in the ventricle, foregut, and rectum. It is not known whether these enzymes originate from bees, intestinal microflora or pollen. However, the ventricle of adult worker bees has 4 endoptidase enzymes that break down protein chains into amino acids. The protease enzymes of queen bees, worker bees and drones are significantly different from each other. A honey bee must consume approximately 10 mg of pollen to produce 4 mg of protein per day during the brood rearing period.

Pollen consumption continues until the bees reach 15-18 days of age. During the spring brood rearing period, 3-6 day old bees use the most pollen; During brood rearing in the summer months, the most pollen is consumed by 9-day-old bees. The amount of pollen consumed during the spring brood rearing period is higher than the pollen consumption in other periods. The amount of pollen consumption is related to the activity of digestive enzymes. The activity of the protease enzyme in bees raised in spring is higher, and this changes with the age of the bees. A similar relationship exists for the enzymes amylase, invertase and lipase. In colonies with weak staff, the brood rearing period for nurse bees takes longer and field services are delayed. In this case, bees age faster, field service periods become shorter, and as a result, the productivity of weak colonies decreases.

The value of pollen of plants in nature for bees may vary depending on the type of plant. The pollen of some plants contains compounds that can be harmful to bees, humans, or both. Pollen from some plant species has low nutritional properties. It is possible to classify pollen as high quality, low quality and very low quality according to its nutritional value.

Among the plants that give high quality pollen, willow, cereals, white clover, poppy, thrips, chestnut, heather, mustard and fruit trees; elm, dandelion, cotton, alder, birch, poplar and hazelnut from plants that give quality pollen; Coniferous trees and especially pine, spruce, fir and cedar can be given as examples of plants with very low pollen quality.

The reason why some pollens have less nutritional value is that they lack some amino acids. Some of these missing amino acids may be essential amino acids that cannot be synthesized by bees and must be obtained externally through food. Arginine, histidine, leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine amino acids are essential for the normal growth and development of bees. Glycine, proline and serine amino acids, although non-essential, promote growth.

Pollen can be collected with pollen traps mounted in front of the hive and stored for later needs. Pollen can be stored for a long time under refrigerator conditions. It has been found that storage time and storage temperature reduce the nutritional value of pollen. Fresh pollen is 100% effective in stimulating the development of hypopharyngeal glands in worker bees. The effect of one-year pollen has decreased by 76%; It is reported that two-year-old pollen does not initiate any development in the hypopharyngeal glands. The nutritional value of pollen stored for three years can be increased to the level of fresh pollen by adding the amino acids lysine and arginine.

Normal growth and development of colonies in spring is often hindered by insufficient pollen supply and toxic pollen. Beekeepers then feed their colonies with additional pollen or pollen substitutes.

1.2.3. Lipids

Lipids are nutritional elements stored in the body fat of bees for use in future starvation situations. Honey bees do not require additional lipid nutrition as long as the lipid content of the pollen is sufficient. It is known that insects do not synthesize sterols. Therefore, lipids must be taken into the body with food. Lipids are essential for growth, metamorphosis and reproduction. They enter the structure of phospholipids. Most insects cannot synthesize cholesterol and other sterols, and they must obtain them from the diet for normal growth.

The tissues of queen and worker bees contain 24 methylene cholesterol as the main sterol. This compound is also present in pollen and royal jelly. Sterols are the building blocks of tissues and cells; They are nutritional elements that are effective in reproduction, metamorphosis of larvae and growth. Cholesterol is a building block of the molting hormone ecdysone, and 24 methyl cholesterol is used for cholesterol synthesis.

1.2.4. Vitamins

Vitamins are essential for the growth and development of living organisms. Vitamin deficiency in the diet causes diseases. Therefore, it is essential to take vitamins in balance with other nutrients.

Pollen is very rich in vitamins, especially water-soluble vitamins. B complex vitamins (folic acid, niacin, pantothenic acid, pyridoxine, riboflavin, biotin, thiamine) and inositol and ascorbic acid (vitamin C), which are essential for insects, are present in sufficient amounts in pollen. Vitamins are necessary for normal growth and development of hypopharyngeal glands in bees, and group B vitamins are necessary for brood rearing activity. Vitamin C, found in large amounts in pollen, is necessary for raising offspring and is essential for bees.

Vitamin E, a fat-soluble vitamin, plays an important role in raising offspring. Pollen and bee bread contain some vitamins A, E and K.

1.2.5. Minerals and Water

Bees meet their mineral needs from pollen, nectar and water. Pollen contains approximately 2.9-8.3% mineral matter. Phosphorus and potassium are the most abundant minerals in bees. But the amount of calcium, magnesium, sodium and iron is much less. Bees also reabsorb salt from the rectum when they need it. The salt provided in this way is probably used to maintain osmotic pressure in the bee body.

Excessive salt in their food has negative effects on bees. In a feeding experiment conducted with sugar syrup containing a low amount of salt (0.5-0.7%), it was concluded that the lifespan of bees was shortened. Adding 0.125% salt to the food caused the caged bees to die within 17 days; The bees in the cage to which 1% salt was added to their food died on the 4th day. On the other hand, honeydew with high salt content has been found to reduce the lifespan of worker bees. The harmful effects of excessive mineral consumption on adult bees are greater during periods when flight is not possible.

Honey bees have to drink water frequently to survive. Bees obtain water from a source outside the hive or from nectar. Water is used to dilute concentrated or crystallized honey, to produce brood food, and to reduce the temperature inside the hive on hot days. In general, water is used the day it is brought to the hive and is not stored in the compartments (Figure 1.4).

Figure 1.4. Water is of vital importance for bees.

Honey bees' need for water depends on air temperature and water loss from the body through the skin, excretory and respiratory systems. Water is a general organic solvent for salts and many organic substances and is absolutely necessary for metabolic activity in cells. Intensification of brood rearing activity in colonies increases water need. Honey bees dilute honey and syrup with a sugar concentration of 50% or more to use as food for their offspring. The humidity level inside the hive must be sufficient so that the egg shell cracks easily, the larva emerges, and it does not dry out. In other words, bees evaporate water in the hive to adjust the temperature and humidity inside the hive, to protect the offspring from excessive heat and to prevent them from drying out. On the other hand, water is also necessary for removing waste products from the body (excretion). A significant portion of the consumed water passes into the intestine to be excreted along with nitrogenous residues and nosema spores coming from the malpighian tubes. In other words, the feces of honey bees are in a liquid state.

Since bees meet their own water needs, it is difficult to determine how much water a colony uses. Water consumption of colonies reaches its highest level during the intensive brood rearing period. To meet the water needs of about a hundred larvae, 5 bees must work to collect water per day. A normal colony requires approximately 200-250 g of water per day during the active brood-rearing period. It is calculated that water consumption in hot and dry weather conditions may vary from 0.5 kg to 4.0 kg per day, depending on the strength of the colony. Bees prefer warm waters with temperatures between 18 ºC and 32 ºC. During the winter months, bees' need for water is extremely low. Bees can maintain the water level in the blood by reabsorbing the water excreted from the body through the rectal glands.

2. FOOD COLLECTION AND STORAGE IN HONEYBEES

2.1. Pollen Collection Activity

In the spring, as nature revives and the flowers that resemble a riot of colors bloom, the pollen on the flowers of plants in nature matures and nectar secretion begins from the nectar glands of the plants. Thus, plants offer a self-service, unimaginably rich and delicious table to bees and other pollinator insects with their pollen and nectar of different colors, compositions and scents. In other words, most plants depend on pollinator insects, especially bees, to ensure their survival by ensuring pollination and fertilization, and these insects depend on plants to meet their nutritional needs. In a sense, there is a mutual benefit relationship, dependence and even condemnation between bees and plants

In order to meet their nectar and pollen needs, bees wander around and visit the flowers at this nature table, which is offered to them in a self-service format. However, bees follow a very interesting path when collecting pollen. For example, if a bee has started to take pollen from sainfoin, it only visits sainfoin flowers until it completes its load, does not show interest in other plants and does not transmit sainfoin pollen to other plant species. Moreover, if the bees first started collecting pollen in the field and contaminated different parts of their body with pollen grains of a plant species, they do not collect some nectar at the same time.

Bees, which start by collecting nectar first, can collect pollen at the same time with the above-described order after completing their nectar load and return to the hive loaded with nectar and pollen at the same time. This is especially seen in flights to flowers that can produce both pollen and nectar at the same time.

Thus, bees meet their own nutritional needs, ensure the continuation of different plant species by preventing them from crossing with each other, and serve all living things in the universe that use or consume plants and their products.

Pollen is the only protein source found in nature for bees. Pollen cannot be used as an energy source like nectar and honey. Without pollen, it is not possible for bees to secrete food for their offspring, to feed the larvae, and for the young larvae to complete their body development. Honey bees usually start their pollen collection flights early in the morning. Pollen is collected from the male organs of the flowers with the help of the bees' mouthparts, legs and the hard hair cover that covers the body. The seasons when colonies collect pollen most intensively throughout the year are the summer months (June, July, August) and the periods when brood rearing activity is high.

The bee that goes out to collect pollen fills its stomach with honey, then leaves the hive and lands on the male organs of the flowers in the field. It collects the pollen from its body with the brush on its middle legs, moistens it with honey from its mouth, and places it in the pollen basket on its legs by rubbing its legs together with special devices called brushes and combs on its hind legs (Figure 2.1).

Flower pollen is collected by field worker bees who have completed their service period in the hive. Depending on the type of source, the weight of the pollen load carried by a bee at a time varies between 12-30 mg; The average is around 15 mg. The pollen load that a bee can carry at a time can be up to one-third of its own body weight. A bee fills its pollen basket in 6-10 minutes, and a pollen expedition that includes collection, transportation and unloading is usually completed in half an hour.

A bee can make an average of 5-8 and a maximum of 11-20 pollen trips per day. A bee that carries 14 mg of pollen each time and makes 5 visits a day carries 70 mg, and a bee that makes 8 trips carries 112 mg of pollen. The amount of pollen transported to a colony is around 35-40 kg per year.

Figure 2.1. Pollen collection activity of worker bees.

Since the pollen densities of plants vary, the weight of the load collected at a time varies depending on the source. If the source used is thrips and elm trees, the pollen load is 12 mg on average, while it is 14 mg in corn, 25 mg in apple and 29 mg in maple trees.

2.2. Nectar Collection Activity

Nectar or honeydew is the raw material of honey. Nectar is a sugary liquid produced by the nectar glands found in the flowers of plants. A worker bee on a nectar expedition sucks the nectar from the flower with its proboscis, stores it in its honey stomach and carries it to the hive (Figure 2.2).

A bee can carry 70-85% of its body weight in nectar at a time. The amount of nectar the honey stomach can take is limited to 70-85 mg. Looting bees can carry as much honey as their own weight each time. Because honey is much denser than nectar. A significant portion of the collected nectar is used for the bee's energy needs during flight, depending on the distance of the source from the hive.

Figure 2.2. The worker bee gets the nectar by sucking it with its proboscis.

A bee can bring an average of 30-40 mg of nectar to the hive each time. It takes 60 nectar trips to fill a single honeycomb chamber. There are approximately 6,000 cells on both sides of a Langstroth type honeycomb and a frame of honey weighs approximately 3 kg. No single flower has enough nectar to fill the honey stomach of a bee. For this reason, bees visit 50-1,000 flowers for a nectar load and visit more than 100 flowers on average. If the source is clover, 1,000-1,500 clover flowers must be visited each nectar visit. Accordingly, bees make an average of 360,000 nectar trips and visit 36,000,000 flowers in order to make one frame of honey. Bees must make an average of 120,000 nectar trips and visit 12,000,000 flowers to produce 1kg of honey.

A bee working for nectar works 7.5-10 hours a day and makes 10-17 nectar visits. The number of trips depends on the distance and richness of the resource. A maximum of 24 nectar trips can be made per day, and this value is considered to be 10 on average. A worker bee that can bring 30 mg of nectar to the hive each time and makes an average of 10 nectar trips a day can carry 30 mg x 10 trips x 20 days = 6,000 mg of nectar in 20 days.

The average flight time for each nectar expedition is 34 minutes and nectar collection time is 21-37 minutes, and the time spent in the hive after the nectar expedition varies between 3-10 minutes. According to research, 25% of bees work only pollen, 58% only nectar, and 17% work both pollen and nectar, that is, they carry both at the same time.

2.3. Propolis Collection Activity

Propolis is also known as bendy wax among the public. It is used for tasks such as narrowing the hive flight hole, closing holes and cracks that require repair, preventing foreign creatures that enter the hive and cannot be thrown out from getting stinky, cleaning and disinfection, etc. (Figure 2.3).

Figure 2.3. Bees narrow the hive flight hole with propolis.

Propolis is a sticky and resinous substance taken orally from the fresh shoots and buds of plants. It is collected mostly in late summer and early winter. Warm days and especially noon hours of the day when propolis is soft are used for the collection process.

The bee that goes on a propolis expedition first uses its mandibles to tear the propolis from the plants with the help of its front legs, transfers it to its front and middle legs and hind legs and finally to the pollen basket. Since propolis is a sticky substance, it is very difficult to collect and empty it.

The collected propolis is not stored in the hive but is used where needed. While the bee that comes to the hive with its load of propolis clings tightly to the honeycomb using its legs, other bees hang with their upper jaws and take the propolis piece by piece from the pollen basket on the carrier bee's leg. The unloading process takes a lot of time and takes up to 30 minutes.

Propolis can be in different colors such as yellow, grey, dark brown and red. Apart from the propolis collected from nature, there is another type of propolis made by bees using indigestible pollen shells, which is called balm. The balm is golden green in color and transparent in appearance; It is obtained by kneading the pollen shells pressed in the proventriculus again in the honey stomach of the bee. This substance obtained is used to remove the roughness and polish the fry's eyes, to give the honeycombs the necessary hardness, and to disinfect the inner surfaces of the eyes where the fry are raised after each hatchling. As the color of the balm darkens over time, the eyes used for raising offspring gradually become darker.

2.4. Water Transportation Activities

Bees have to consume water in order to keep the temperature and humidity inside the hive within the desired limits, to continue their brood raising activities without interruption, to consume crystallized honey and finally to live. 12 units of water are needed to consume one unit of honey. Bees generally do not store the water they carry in their crops in their honeycomb cells.

The average time spent for a water expedition is 5 minutes. A bee makes an average of 50 and at most 100 water trips a day. Bees coming to the hive loaded with water transfer their load to the worker bees in the hive, rest for a short time, take some honey from the honeycomb cells or from other bees, and after identifying the location of the source with their dances, they set off on a new expedition.

Research shows that 85% of bees prefer warm water to cold water and do not choose a source as long as the temperature of the water is between 15-38 ºC.

To date, the amount of water a bee can carry has not been determined with certainty. However, a bowl filled with three grams of honey contains two grams of water. In other words, the weight of water corresponds to 2/3 of the weight of honey. Since a worker bee can carry 75 mg of honey, the maximum amount of water a bee can carry is 50 mg. However, on average, a worker bee carries 25 mg of water each time. A worker bee responsible for carrying water can carry 1,250 mg of water by making an average of 50 trips per day.

2.5. Pollen and Nectar Storage

Field bees, returning to the hive loaded with pollen, walk on the honeycombs for a while, and with special dances they perform, they inform other bees about the richness of the source, its direction and its distance from the hive. It feeds a little and goes to the eye where it discharges its load. Pollen loads are generally deposited on the edges of the brood area and on the edge frames of the hive. The chamber where the pollen will be discharged may be empty or already partially filled with pollen. Clinging to the edge of the eye with its front legs, the pollen-laden bee hangs its middle and hind legs into the eye and discharges the pollen it brought into the honeycomb eye with certain leg movements. The emptied pollen pellets are crushed, dispersed and threshed by another young worker bee using the mandibles. Then, the bee compresses the pollen inside the eye with its head and protects it by covering it with a thin layer of honey after pressing it so that it does not get air. This stored form of pollen is called "bee bread".

While field bees returning from the pasture loaded with flower pollen unload their loads directly into the cells of the honeycomb; Field bees come to the hive loaded with nectar and transfer the nectar they bring to the young worker bees in the hive. The loaded bee that comes to the hive first walks a little, gives information about the resource to other bees with its dances, and transfers its load to a young bee by mouth. The bee that unloads its load leaves the hive either immediately or after taking some food. The nectar taken from the field bees is stored in the honeycomb chamber after it is matured by the young workers in the hive. Young worker bees, who undertake the ripening of nectar, reduce the water content of the nectar during this process and change the sugar structure of the nectar with the effect of enzymes secreted from their bodies.

REFERENCES

Ambrose, J. T., 1993. Management for Honey Production. The Hive and Honey Bee, Dadant and Sons, Hamilton IL. USA, Chapter 14, p1601-655.

Buttler, C. G., 1984. The Honey-Bee Colony-Life History. The Hive and Honey Bee Dadant and Sons, Hamilton IL. USA, p39-74.

Dadant, C. C., 1993. Beekeeping Equipment. The Hive and Honey Bee, Dadant and Sons, Hamilton, Il. USA, p537-573.

Dietz, A., 1993. Nutrition of The Adult Honey Bee. The Hive and Honey Bee, Dadant and Sons, Hamilton, ChapterII. p 38.

Doğaroğlu, M., 2009, Modern Arıcılık Teknikleri. Doğa Arıcılık San. Tic. Ltd. Şti., Tekirdağ, İstanbul, 270s.

Frizzera, D., Del Fabbro, S., Ortis, G., Zanni, V., Bortolomeazzi, R., Nazzi, F., & Annoscia, D. 2020. Possible side effects of sugar supplementary nutrition on honey bee health. Apidologie, 51(4), 594-608.

Genç, F., Dodoloğlu, A., 2011. Arıcılığın Temel Esasları. Atatürk Üniversitesi Yayınları No: 931, Ziraat Fakültesi Yayınları No: 341, Ders Kitapları Serisi: 88, Atatürk Üniversitesi Ziraat Fakültesi Ofset Tesisi, Erzurum,-2011, 386s.

Güler, A., 2017. Bal Arısı (Apis mellifera L.) Yetiştiriciliği, Hastalıkları ve Ürünleri Kitabı. Bereket Akademi Yayınları, Azim Matbaacılık, Büyük San. 1. Cad. Alibey İşhanı, 99/33, İskitler/Ankara, 419s

Kim, Y. S., & Smith, B. H. 2000. Effect of an amino acid on feeding preferences and learning behavior in the honey bee, Apis mellifera. Journal of insect physiology, 46(5), 793-801.

Korkmaz, A., 2013, Anlaşılabilir Arıcılık Kitabı. Samsun Gıda Tarım ve Hayvancılık İl Müdürlüğü Yayını, Türker Matbaacılık San. Ve Tic.. Ltd. Şti., Pazar Mah., Şeyhhamza Sok., No:31, İlkadım, Samsun, 330s.

Liao, C., Xu, Y., Sun, Y., Lehnert, M. S., Xiang, W., Wu, J., & Wu, Z. 2020. Feeding behavior of honey bees on dry sugar. Journal of insect physiology, 124, 104059.

Lois, A. N., Jaffe, B., & Guédot, C. 2020. Supplemental feeding solutions do not improve honey bee (Hymenoptera: Apidae) foraging on cranberry (Vaccinium macrocarpon). Journal of Apicultural Research, 59(5), 783- 790.

Öder, E., 1989, Bal Arılarının Beslenmesi. Hasad Yayıncılık, Peykhane Cad., Güneşin Han, No:55/6, Sultanahmet-İstanbul, 327s.

Paray, B. A., Kumari, I., Hajam, Y. A., Sharma, B., Kumar, R., Albeshr, M. F., ... & Khan, J. M. 2021. Honeybee nutrition and pollen substitutes: A review. Saudi Journal of Biological Sciences, 28(1), 1167-1176.

Ricigliano, V. A., Williams, S. T., & Oliver, R. 2022. Effects of different artificial diets on commercial honey bee colony performance, health biomarkers, and gut microbiota. BMC veterinary research, 18(1), 1-14.

Root, A. I., 1983, ABC and XYZ of Bee Culture. The A. I. Root Company, Medina, Ohio, USA, 712p.

Silici, S., 2009, Bal Arısı Biyolojisi ve Yetiştiriciliği. Eflatun Yayınevi, Gazi Mustafa Kemal Bulvarı, 118/4, Maltepe- İstanbul, 235s.

Topal, E., Mărgăoan, R., Bay, V., Takma, Ç., Yücel, B., Oskay, D., ... & Kösoğlu, M. 2022. The Effect of Supplementary Feeding with Different Pollens in Autumn on Colony Development under Natural Environment and In Vitro Lifespan of Honey Bees. Insects, 13(7), 588.

CHAPTER 2

SPRING CARE FOR HONEYBEES

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1. INTRODUCTION

Beekeeping is a branch of agricultural production and as a result of beekeeping activities; Products such as honey, royal jelly, swarm, queen bee, bee venom and beeswax are obtained. The aim of beekeeping is to increase honey production by maximizing the number of worker bees during periods when nectar flow is most intense. In order to produce efficiently in beekeeping, modern hives should be used, young and hard-working queen bees should be kept in the colony, diseases and pests should be controlled, and the colony should be fed with additional feed when necessary. In short, seasonal work required in beekeeping should be done on time (Arslan, 1987; Genç, 1994; Doğaroğlu, 2004; Güler, 2006; Şahinler et al.2022). Work in the spring period is of great importance for colony continuity. Proper care and feeding of the colony during the spring period, entering the honey season with strong staff, increasing honey yield and maintaining a healthy life of the colony depend on the work done during these periods. We can list the work to be done in this period under main headings; ; It is to open and examine the hive to check how the bees spend the winter, the amount of food available in the hive, whether there is a queen bee, if there is a queen bee, the egg laying status, the number of worker bees, whether there is moldy honeycomb in the hive, whether there are diseases and pests in the hives (Altındiş, 2001;Mata, 2018; Genç,1993).

2. Procedures Done In Sprıng Care

The purpose of spring inspections of colonies is; It is to open and examine the hive to check how the bees spend the winter, the amount of food available in the hive, whether there is a queen bee, if there is a queen bee, the egg laying status, the number of worker bees, whether there is moldy honeycomb in the hive, whether there are diseases and pests in the hives.

2.1. Bottom board Control and Cleaning

The hive bottom board can be cleaned when the bees are in flight. An attempt is made to obtain information about the condition of the colony by examining the crumbs and residues seen on the bottom board. Sometimes the weather conditions are not suitable for opening the hive completely outside. In these days when the air temperature is not sufficient, examinations can only be made on the bottom board in early spring to prevent the larvae (maggots) in the honeycomb cells from getting cold and dying. In addition, bottom boards that accumulate moisture and water need to be replaced urgently.

2.2. Frame Control

In frame control, moldy, overly browned and broken frames with honeycombs are removed from the hive and replaced with clean frames from the previous year. If there is no processed honeycomb, the basic honeycomb frame to be given is placed last. If broken combs are left in the hive, the bees will make male bee eyes during the repairs they make here, causing the number of drones to increase in the colony. The queen bee does not willingly lay eggs in brown and moldy combs, which causes the colony to weaken and product loss.

2.3. Control of Queen Bee

In order for a colony to continue its continuity, there must be a queen bee in each colony. A queen bee should be introduced to a colony that has lost its queen bee during the winter or for various reasons. If this is not possible, the queen should be combined with another colony. It is not possible for the colony to survive without its queen (Genç, 1994; Doğaroğlu, 2004; Güler, 2006). Whether or not there is a queen bee in the colony directly affects the continuity of the colony. If the queen bee cannot be seen during the checks, the daily egg status is checked. If there are daily eggs in the colony, there is most likely a queen bee. If both the queen bee and the daily egg cannot be seen, the colony does not have a queen. In this case, if possible, a new queen should be given to the colony or this colony should be merged with another colony.

2.4. Merging of weak and motherless colonies

It should not be forgotten that in technical beekeeping, it will always be efficient to work with strong colonies all year round (Wheeler and Robinson, 2014; Oskay and Oskay, 2017). While both honey and swarm can be obtained from a colony in the same season by keeping the colonies strong, this is not possible in weak colonies (Köseoğlu et al., 2021). For this reason, one of the necessary procedures for colonies coming out of winter in the first spring is to strengthen weak colonies by combining them. However, when combining, some factors should be taken into consideration (Genç, 1994; Güler, 2006). The colonies that are combined must be healthy. If there is a queen bee in both colonies, the young and healthy queen bee should be left in the colony and care should be taken to ensure that there is a queen bee in the colony. The merging process should be done in the evening, that is, when all the bees are in the colony. After the merging process, the remaining hive, honeycomb and other parts should be removed from the apiary immediately. (Genç,1994; Güler,2006).

Although there are different methods for joining, the most reliable method is the joining with newspaper paper. In this method, the colonies to be combined are placed on newspaper paper, such as a dividing board, next to the last comb inside the brood chamber of the strongest colony in the evening hours. Before placing the newspaper paper, small holes are opened on it with a small drilling tool or a nail, these holes gradually release the unique smell of the different colonies. It allows the honeycombs to mix on both sides and for both colonies to get used to the pheromone of the existing queen bee (Köseoğlu, 2009). After these procedures, the combs taken from the other colony are placed next to the newspaper paper and finally, the top of the combs and the bottom of the cover board are covered with newspaper paper. 1-2 days after assembly, the newspaper particles in between are removed and the honeycombs within the colony are rearranged (Genç, 1994; Güler, 2006).

2.5. Disease and Parasite Control

In a study, it was reported that combating bee diseases and feeding colonies with additional feeds with vitamins and pollen were effective on viability, wintering ability and spring development (Akyol et al., 2006). During the spring, colonies should be examined for diseases and pests. If there are more dead bees than normal in the colony and it is known that the amount of food in the hive is sufficient, then the disease should be suspected. In the apiary, care should be taken against nosema, foulbrood and parasitic diseases that can be seen throughout the year. When any disease is observed or suspected, an expert should be consulted to control and combat the disease and action should be taken in accordance with the expert's opinions and recommendations.

Since drug residues in honey have become an important problem recently, colony pesticides should not be used as a preventive treatment in the spring, regardless of whether there is a disease or not, contrary to what is often done (Uygur and Girişgin, 2008). Since some countries in the European Union, to which we export honey, impose zero tolerance limits on a group of antibiotics in honey (Sunay et al., 2003), honey producers in particular should show the necessary sensitivity to this issue.

2.6. Controlling Varroa

One of the things that need to be done in the spring period is to combat the varroa parasite, which has caused great colony and productivity losses in the world in recent years (Genç, 1990; Genç, 1994; Doğaroğlu, 2004; Güler, 2006). Varroa destructor is a pest that affects honey bees all over the world, affects the immune system of the bees, and especially affects the fat tissue, which has an important role in pesticide detoxification (Ramsey et al., 2019). If varroa control is not carried out, colony losses will be inevitable. In the fight against Varroa, the drug with the same active ingredient should not be used every year. By using drugs with the same active substance every year, the varroa parasite will develop resistance to this drug (Huang, 2012). For this reason, care should be taken to use drugs whose active ingredients are different each year. In addition, in order to prevent pesticide residues in honey, spraying should be done in the early spring period, in other words, it should not be done in the summer, in other words before the honey harvest. Another point to be considered when spraying is to apply the pesticide at the required dose. If possible, natural products and organic acids should be preferred among the drugs to be used (Olgun et al., 2020).

2.7.Control of Nutrient Status in the Hive

The purpose of nutritional control is to determine the amount of honey and pollen in the hive. In cases where the food stock is insufficient during the control in early spring, it is more appropriate to feed with cake or dark syrup made from honey and powdered sugar. Feeding with this syrup accelerates the development of the colony and ensures that the honey season is entered with strong colonies.

Spring Feeding and Its Importance: After the number of bees emerging from winter in spring is determined and the necessary arrangements are made, a feeding program is applied to the colonies. Spring feeding is a feeding done in case the food resources in the hive are insufficient in terms of quality and quantity and to stimulate the development of the offspring. In the spring, when the weather is not warm enough, cake feeding should be done. When the weather gets warmer, feeding with syrup can be started. If the weather is cold during syrup feeding, the syrup should be thick (2 or 3 parts sugar + 1 part water) and filled into the honeycomb cells.

There are some important basic principles of colony feeding.

These;

1. If there is a necessity, additional feeding should be done. If the flora is good in nature, there is no need to feed it.

2. Feeding should generally be done in the evening and syrup should not be spilled around.

3. Instead of giving too much syrup to the colony at once, feeding should be done little and often.

4. Hives should not be kept open for a long time during feeding.

5. Feed should be given in suitable containers inside the hive and feeding should not be done outside.

2.8.Swarm and Swarm prevention

As we mentioned before, one of the important tasks of spring care is swarming in honey bees. Swarming is the reproductive instinct of honey bees, and in order to continue the generation, some of the colony members leave the hive together with the queen bee and form a new colony. Natural swarming, which occurs when nectar flow begins, reduces the strength of the mother colony, thus reducing honey yield. In addition, if the swarming continues, the young worker bees that act as incubators in the colony emerge with the swarm, disrupting the incubation activity in the parent colony and as a result, lime disease may occur. In order to avoid such negativities in beekeeping, precautions should be taken against natural swarming, and if the number of colonies is desired to be increased, artificial swarming (division) should be made.

3.CONCLUSION

Seasonal maintenance work is important for a profitable and efficient beekeeping production. One of the seasonal maintenance tasks in beekeeping is spring care and feeding. Spring maintenance of honey bee colonies is of great importance for economical bee farming and the continuity of the colony. The work to be done during this period includes cleaning the bottom board of the hive, how the bees spend the winter, the amount of food available in the hive, whether there is a queen bee, if there is a queen bee, the egg laying status, the number of worker bees, whether there is moldy honeycomb in the hive, whether there are diseases and pests in the hives. To check, open the hive and inspect it. (Altındiş,2001;Mata, 2018; Genç,1993).

REFERENCES

Akyol, E., Yeninar,H., Şahinler, N., Guler ,A. (2006). The Effects Of Additive Feeding And Feed Additives Before Wintering On Honey Bee Colony Performances, Wintering Abilities And Survival Rates At The East Mediterranean Region, Pakistan Journal Of Biological Sciences 9 (4): 589-592, 2006

Altındiş, K. (2001). Arılarda Sonbahar Bakımı ve Kışlama. Uludağ Arıcılık Dergisi,2687-5594,Cilt1, Sayı 2.

Arslan, S. (1987). Effects Of Additive Feeding with Proteins on Colony Development, Msc. Thesis. Institute Of Science, University Of Cukurova.

Doğaroğlu, M. (2004). Modern Arıcılık Teknikleri, Doğa Arıcılık Tekirdağ, 296 S.

Frias BED, Barbosa CD, Lourenço AP, (2016). Pollen Nutrition İn Honey Bees (Apis Mellifera): İmpact On Adult Health. Apidologie, 47(1): 15-25

Genç, F. (1990). Effects Of Varroa Infestation On Wintering Ability And Feeding, Flowering Area And Weight Of Queens At Emergence On Colony Performance, Doctoral Thesis, Agricultural Faculty Of Ataturk University, Erzurum.

Genç, F. (1994). Arıcılığın Temel Esasları. Atatürk Üniversitesi Ziraat Fakültesi Ofset Tesisi.Yayın No: 149, Erzurum, 286 S.

Güler, A. (1999). Importance Of Sugar In Feeding Of Honeybee (Apis Mellifera L.) Colonies. First Beekeeping Symposium In Turkey, Kemaliye / ERZİNCAN

Güler, A. (2000). The Effects Of Narrowing Of Hives And Additive Feeding On Some Physiological Characteristics Of Honeybee Apis Mellifera L.) Colonies, Türk Journal Of Veterinarian And Animal Science 24(2000)1-6@ TÜBİTAK

Güler,A. (2006). Balarısı (Apis Mellifera) Ondokuz Mayıs Üniversitesi.Ziraat Fakültesi.Ders Kitabı No:55 Samsun.

Haydak, M.H. (1970). Honey Bee Nutrition. Annual Review Of Entomology 15, 143–156.

Huang, Z. (2012). Pollen Nutrition Affects Honey Bee Stress Resistance. Terrestrial Arthropod Reviews 5 (2): 175189.

Kösoğlu, M. (2009). Teknik Arıcılık Koşulları Ve İlkbahar Bakımı. Hasad Hayvancılık Dergisi,2009 Sayı 287.

Kösoğlu, M., Topal, E., Tunca, R. İ., Yücel, B., Yıldızdal, İ. (2019). Bal Arılarında Kışlama Öncesi Farklı Beslemenin Koloni Gelişimine Etkileri, Anadolu Ege Tarımsal Araştırma Enstitüsü Dergisi, 29(2), 85-92.

Mata, M. (2018). Two Approaches To Protecting Bees: Bee Nutrition İn A Changing Climate And Community Outreach As A Tool For Bee Conservation. Thesis Submitted To The Graduate Faculty Of North Carolina State University İn Partial Fulfillment Of The Requirements For The Degree Of Master Of Science, Raleigh, North Carolina.

Olgun, T., Topal, E., Güneş, N., Oskay, D., Sarıoğlu, A. (2020). Bal Arılarında (Apis Mellifera L.) Beslenmenin Hastalık ve Zararlılarla İlişkisi, Anadolu Ege Tarımsal Araştırma Enstitüsü Dergisi, 30(1), 103-116.

Oskay D., Oskay GS. (2017). Bal Arısı Ek Beslemesinde Sorunlar ve Çözüm Önerileri, Arıcılık Araştırma Dergisi, 9(1), 1-8.

Oskay, A.G.D. (2003). Balarısı Kolonilerinde Peteksiz Kışlama, Uludağ Arıcılık Dergisi, 3(1), 41-43.

Radev Zh, Lioliosv,Tananaki C. (2014). The İmpact Of The Nutritive Value Of Pollen On The Development, Reproduction And Productivity Of Honey Bee (Apis Mellifera L.), Bulg. J. Agric. Sci., 20: 685-689.

Ramsey, S. D., Ochoa, R., Bauchan, G., Gulbronson, C., Mowery, J. D., Cohen, A., Vanengelsdorp, D. (2019). Varroa destructor feeds primarily on honey bee fat body tissue and not hemolymph. Proceedings of the National Academy of Sciences, 116(5), 1792-1801..

Rhodes, J. (2000). Apiary Management For Winter / Early Spring Pollination. DAI/154, Agnote ISSN 1034-6848. NSW Agriculture.

Somerville, D., (2000). Honey Bee Nutrition And Supplementary Feeding. Agnote DAI/178. NSW Agriculture.

Sunay E.A., Altıparmak Ö. Doğaroğlu M., Gökçen,J. (2003).Türkiye'de Ve Dünyada Bal Üretimi Ticareti Ve Karşılaşılan Sorunlar. II. Marmara Arıcılık Kongresi, 28-30 Nisan, Yalova, 151-183.

Şahinler N., Kaya Ş. (2001). Bal Arısı Kolonilerini (Apis Mellifera L.) Ek Yemlerle Beslemenin Koloni Performansı Üzerine Etkileri, M.K.Ü. Ziraat Fakültesi Dergisi, 6(1-2), 83-92.

Uygur Ş. Ö., Girişgin, A. O. (2008). Bal Arısı Hastalık ve Zararlıları, Uludağ Arıcılık Dergisi, 8(4), 130-142.

Wheeler MM, Robinson GE. (2014). Diet-Dependent Gene Expression İn Honey Bees: Honey Vs. Sucrose Or High Fructose Corn Syrup, Scientific Reports, 4, 5726.

Şahinler ,N.;Toy, N.Ö.; Demirhan,S (2022).Balarilarinda Sonbahar Bakimi Ve Kişlatma. Arı ve Arıcılık Kitabı 4. bölümü. S:40-51. İksat.-Yayın evi.

CHAPTER 3

EFFECTS OF CLIMATE CHANGE ON FRUITS POLLINATION BY HONEYBEES

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1. INTRODUCTION

In parallel with the social developments in modern fruit growing, fruit areas have reached large sizes, the diversity in production and production purposes has increased and the methods used have played a major role in all these. In the expansion of production areas, new understandings in terms of different cultivation systems and breeding have emerged and different methods have been applied. With the development of standardization, cold storage, deep freezing, canning and fruit juice industry, very large commercial orchards were required to meet the needs. Naturally, as a necessity of intensive fruit growing, old traditional planting and training systems have been abandoned in order to increase work efficiency and to obtain more and cheaper products from unit area, and efforts have been made to find planting and training systems suitable for the characteristics of the growing place, production purposes and economic conditions.

Pollination is the event that occurs in plants that reproduce sexually and the pollen is transported to the flower's stamen (Yakar and Bilge 1987). According to the morphological and physiological structure of the flowers, pollination occurs in two different ways: self-pollination (autogamy) or foreign pollination (allogamy). The transportation of the inflorescence from the anther to the stigma is carried out by various mediators. Wind, water and gravity are abiotic; insects, birds and mammals are biotic floral powder carriers (Özçağıran 2002).

Bees, especially honey bees, are the leading pollinator insects (Figure 1). Perhaps the most important of the benefits provided by honeybees is their contribution to fertilization and crop increase as a result of pollination in flowering plants and fruit trees (Erdoğan ve Dodoloğlu, 2003; Genç and Dodoloğlu 2002). Honey bees are beneficial insects belonging to the order Arthropoda, class Insecta, order Hymenoptera, family Apidae and genus Apis (Ötleş 1995). In addition to Apis mellifera L., which is known as European bees and spread almost all over the world, there are Apis florea L., Apis dorsata L. and Apis cerena L. species (Özbek 1992).

Figure 1: honeybee collecting pollen

Every living thing on Earth has a role in maintaining balance in the ecosystem. Beekeeping, which is developing day by day in our country, has an important place in the ecosystem. In crop production, pollination occurs in various ways. For example; by wind, by some insects. The most important insects involved in pollination are bees. Many studies have proven that bees help pollination for a sustainable environment and increase the productivity of plants (Topal et al., 2013). However, some studies have emphasized that they prefer pollen collected only from female flowers, while others prefer pollen collected only from male flowers. The results show that honey bees search for and collect both fertile pollen from male flowers and sterile pollen from female flowers. The reason for this is that flowers found in nature contain scent clues of nectar and pollen. These scents are identified by pollinators during their first food search and become embedded in their scent memories. In bee behavior, odor-induced behavior has been investigated in honey bees because bees can detect pollen odors. It has been emphasized that bees perceive pollen odors with their behavioral characteristics and allow pollination at certain levels even if pollen is their only food source (Goodwin and Congdon;2018). Farina et al.

(2007) put forward a hypothesis in their study that bees increase pollinator visits to sunflower plants with their scent behavior. Although the history of beekeeping dates back to many years, little was known about the role of bees in crop production. Information about the important role played by bees in pollination dates back to the mid-eighteenth century. However, the theoretical use of this information was seen in the 1900s (Lorenz,2021). Honey bees spend their time collecting nectar and pollen during the day in line with their own needs. During this process, they carry the pollen that adheres to them from one flower to another (Erdoğan et al, 2009; Şahinler, 2000; Kekeçoğlu et al., 2015). Pollination of 16% of flowering plants in the world and approximately 400 agriculturally produced plant species is carried out by honey bees (Karaman, 2018).

There is very little pollen in primary flowers that bloom early in spring. However, this does not constitute a situation that would prevent pollination. In order for the fruit size to reach its maximum level, all female organs on the flower must be fertilized. Flowers grow very quickly after fertilization (Süzer 2005). According to Moore (1964), the strawberry's pollen acceptance period is reported to be 7 days after the flower opens. Darrow (1966) reported that the pollen acceptance period can be up to 10 days in cold periods, but the number of seeds in each fruit will decrease as time goes by. There is very little pollen in primary flowers that bloom early in spring. However, this does not constitute a situation that would prevent pollination. Since the stigma can remain receptive for several days, bees pollinate these primary flowers by taking the necessary pollen from later blooming flower clusters. In order for the fruit size to reach its maximum level, all female organs on the flower must be fertilized. Flowers grow very quickly after fertilization (Aybak 2000). Honey bees not only contribute to the increase in quantity and quality of products by pollinating cultivated plants, but also pollinate wild plants in nature, causing these plants to multiply and spread and increase diversity (Erdoğan, 2019; Banaszak 1986).

In almost all foreign pollinated plants and in most of the self-pollinated plants, pollination by bees causes both yield increase and quality increase in the product. Otherwise, deformed, distorted, tasteless and low market value fruits are formed (Erdoğan and Dodoloğlu, 2004; McGregor 1976). In order to realize high quality and abundant fruit set in fruits with erect flowers, pollination must be realized in a very good way. Mel "nichenko (1977) stated that if the necessary importance is given to pollination, yield increases of 45-50% in sunflower, 50-60% in clover, apple and pear, 75-90% in cucumber, 95-100% in melon and watermelon, 25-30% in tomato and grape, 35-40% in sainfoin, clover and vetch can be achieved. A honey bee visits an average of 100 flowers in each tour and collects 5 million pollen pieces weighing approximately 20 mg.

A bee makes about 5 to 10 trips a day over different species. A colony makes approximately 2 million flights per year and in return 40 kg of pollen is collected. All these data show that honey bees have a unique place in pollination (Genç and Dodoloğlu, 2002). Yakovleva (1975) states that honey bees have been bred in Russia in recent years to be used in pollination of some plants and that the value of the product obtained as a result of bee pollination in areas where intensive agriculture is practiced is 10-15 times higher than the value of honey produced by these bees; Crane (1972) states that it is 20 times higher.

2.Effects of climate change on fruit growing

Since fruit growing is a perennial agricultural activity, it is more affected by global climate changes. In the cultivation of fruit species, in order to obtain a high and quality product with balanced flowering and fruit set, cooling is required at different hours during the winter rest period, although it varies depending on the species. With the data of 4293 weather forecast stations in the world, the amount of cold that exceeds 90% of all years for safe winter cooling was estimated using a dynamic model. It has been reported that in warm and temperate regions, there may be severe decreases in the current winter cold that will potentially threaten production, while there may be an increase in cold regions (Luedeling et al., 2011). However, when considered in general, global warming has the potential to increase air temperature during the winter period, and these predicted temperature changes will have negative effects in regions where most fruit species, vine and nut cultivation are common (Webb et al., 2007; Campoy et al., 2011).

It has been reported that in grape cultivation in the Margaret River region of Australia, flower bud burst is delayed if the cooling need is not met due to the increase in temperature (Webb et al., 2007). It has been reported that in order to be better prepared for the potential effects of climate change, it would be appropriate to cultivate fruit varieties with lower chilling needs (Luedeling et al., 2011). It is estimated that there will be significant temperature increases, especially in the summer months (Giorgi and Lionello, 2008).

The increase in temperature during the winter months may cause problems such as winter dormancy and bud awakening in fruit species, and twin fruit formation during the flower bud differentiation period in the summer. When the research on twin fruit formation, which reduces fruit quality and market value in cherry cultivation, is examined; In regions with hot climates, during the flower bud differentiation period of the previous year, a normal single pistil is formed at 25 °C, while the rate of double pistils increases at 30 °C (İmrak and Küden, 2012), and at temperatures of 35 °C and above, this rate is 80%. It was determined that it increased to (Beppu and Kataoka, 1999; Engin and Ünal, 2004).

The effects of global warming on grapevine phenology in Australia were modeled for 2 commercially important varieties in 6 regions. In the Coonawarra region, it was determined that the bud burst time of Cabernet Sauvignon will be 4-6 days earlier in 2030 and 6-11 days earlier in 2050. It is thought that the harvest time will be earlier in all regions studied and according to the highest temperature scenario, the harvest may be 45 days earlier in the Coonawarra region by 2050 (Webb et al., 2007).

Extreme changes in air temperatures also have a negative impact on the flowering period of fruit species (Omoto and Aono, 1990; Guédon et al., 2008).Changes in flowering phenology will affect pollination and fruit set, and may cause problems in production by increasing the risk of late spring frosts (Zavalloni et al., 2004).

In a study on the effects of global climate change on apple cultivation in the Hesse region, it was reported that between 2031 and 2060, trees will start flowering 6-8 days earlier and there will be a significant increase in the risk of late spring frost during the flowering period (Braun and Müller, 2012).

Climate change impacts on safe winter cold temperatures in most temperate fruit-growing regions vary quantitatively between global climate models and greenhouse gas emissions scenarios (Luedeling et al., 2011). Cold injury is the main problem limiting fruit production in the Okanagan valley (USA) and historical records from 1916-2006 show that severe lethal cold injury occurred 16 times. Although this is the 4-month period when crops are most susceptible to cold damage, the periods of risk for each variety vary. If climate changes continue, grape, apple and cherry production in this region is expected to decrease, while pear, apricot and peach production areas may expand (Quamme et al., 2010). Low temperature tolerance in winter is the result of genotype interaction with the environment, affecting plant development and metabolic activity under continuous low temperatures and freezing conditions (Fennell, 2014).

Temperature change and ozone level change can have a significant impact on the post-harvest quality of products by changing quality parameters such as sugars, organic acids, synthesis of antioxidant compounds and hardness, as they directly affect photosynthesis, as well as causing morphological and physiological disorders (Moretti et al., 2010). The possible effects of climate change on anthocyanin and titratable acidity levels of grapevine cultivars grown in Western Australian wine regions were estimated for the years 2030-2050 and 2070, and it was stated that they would be negatively affected by global warming under current management practices (Barnuud et al., 2014). As a result of the extreme temperature increase in the summer period, the grape harvest time is brought earlier and the high temperatures at harvest time negatively affect the grape quality (Webb et al., 2007).

Looking at historical data on Hungarian grape growing regions, extreme weather events such as floods, frosts, droughts, heat waves, which are now occurring more frequently, along with the trend of increasing average annual temperature, have been observed under global climate change. Changing climatic conditions in the Carpathian basin may cause negative economic consequences and stress effects by affecting quality and quantity (Szenteleki et al., 2012).

The most noticeable change in climate is the temperature increases and precipitation in summer. According to the data of the Turkish Statistical Institute (TUIK) due to the drought experienced in our country in 2007, the loss rates in some fruit species were 39.1% for olives, 33.3% for pistachios, 19.8% for hazelnuts, 9.7% for grapes, and 27.6% for figs has happened. It is stated that there are significant changes in phenological periods as a result of the effects of climate change in the production of almonds, pistachios and walnuts grown in California (Pope et al., 2014).

In the UK, studies are being carried out to determine energy efficiency within the food marketing system. In particular, it has been stated that the import of seafood and vegetables by air is a way to be avoided as it causes a large amount of greenhouse gas production and that local production should be increased as a solution. Compared to locally sourced produce, air imported produce was found to emit 9.66 kg more CO2 (Michalský and Hooda, 2015). Future research should aim to minimize seasonal variations and to achieve sustainable and profitable production of high quality fruit for special uses in the face of water and labor shortages, changes in consumer preferences and global competition (Keller, 2010).

3. Impacts of Climate Change on Honey Bees

Changes in global climate are likely to affect the behavior and lifestyle of many animals, including insects. For insects, an increase in temperature and humidity means an increase in growth rate, displacement rate and reproductive capacity, and these changes can also affect ecological processes taking place in nature.

Changes in the climate will also change the character of the environment in which living things live, and these changes will indirectly affect the behavior of insect societies living in that ecological environment. It is thought that climate changes will cause some important differences in the physiology and geographical distribution limits of insects. In particular, changes in temperature and humidity affect the function of insect metabolism, reproductive capacity, feeding habits and, accordingly, its distribution (Akbulut, 2000). It is thought that the effects of changes in temperature and humidity on the life cycle of pine cotton wool (Marchalina hellenica Genn) (Figure 2), which provides the formation of pine honey, will be a great threat especially to our country, which produces around 90-92% of the world's pine honey.

Biodiversity provides insurance against adversities and changes in environmental conditions. In a study investigating the effects of the increase in winter temperature (1.5-9.5 °C) on live weight and development in 9 bee species, it was stated that there were increases in weight losses and energy consumption, and that some species' life cycles ended in the spring due to these reasons. Climate change may cause living species living in a region to leave the area they live in, as well as the establishment of new invasive species that are not native to the region and the extinction of some species from the world (Doğan et al., 2010).

Figure 2: Marchalina hellenica Gennadius
(https://www.invasive.org/browse/detail.cfm?imgnum=1329019#)

When we look at the historical process of the bee, it is seen that it has genetics that can adapt to new environmental conditions such as temperature. Climate change may have a direct impact on honeybee behavior and physiology. Decreasing flower quality in the environment may reduce colony development and therefore productivity. Honey bees may have to search for new food sources as a result of new competitive relationships between species and races. It should not be forgotten that in these new environments, indigenous genetic resources will come to the fore (Le Conte and Navajas, 2008).

Although differences are expected in phenological responses to climate change among species, these responses occur at the same rate between plants and their pollinators. Since wild bees also take part in pollination, their adaptation to climate changes becomes important (Fründ et al., 2013). It has been stated that plant flowering and pollination activity time is strongly affected by temperature (Hegland et al., 2009).

If climate change affects pollinator-dependent crop production, it will have significant implications for global food security. This is because insect pollination contributes to the production of 75% of leading global food crops. Whether global warming causes indirect effects on plant pollination services has been investigated. The study found that a warming of between 2.4 ºC and 6.4 ºC by 2099 on watermelon pollination would result in a 14.5% decrease in pollination managed by honeybees and an increase in pollination provided by native wild species. Researchers stated that native biodiversity should be preserved to minimize the effects of climate change, because plant pollination would decline faster without native pollinators (Rader et al., 2013).

Honeybees are the most economically important pollinators of agricultural products. Honey bees are creatures with high adaptability to temperature changes in their environment. While climate change causes a decrease in the quality of flower pollen and nectar in the current ecology, it may have a direct impact on bee behavior and physiology and the quantity and quality of bee products. Honey bees may have to search for new food sources as a result of competitive relationships between species and races, and native genetic races may be more advantageous in this competition (Le Conte and Navajas, 2008).

Changes in the global climate will likely affect the behavior and lifestyles of many animals, including insects. Increase in temperature and humidity for insects, It means increasing the development rate, displacement speed and reproductive capacity. In the study, which examined the development of 597 colonies of five honeybee species with 16 different genetic origins in eleven European countries for two years, it was determined that the brood rearing period was shorter in northern countries. It has been determined that genotype and environment significantly affect colony development, and are especially important in terms of adult bee population and wintering ability (Hatjina et al., 2014).

The importance of biodiversity has been increasing in recent years. Honey bees are creatures with high adaptability. In this context, the future of native bees of the region is endangered by bringing breeds that are thought to be productive to the region due to reasons arising from development policies in developing countries and other countries. For this, local genetic resources must be kept under control with appropriate genetic models and breeding strategies (Zokour and Bienefeld, 2014). In the study conducted under the conditions of the Aegean Region, the significant deviations of the climate from the long-term average during the experiment greatly affected the performance of the colonies of Caucasian bee, Aegean ecotype of the Anatolian race and Italian race hybrids. It has been stated that if the effects of climate change continue in the region, it will become impossible to grow the Caucasian genotype in the region (Koç and Karacaoğlu, 2012).

Climate change reduces survival, reproduction and habitat. For this reason, ecologists work to manage biodiversity in sustainable agricultural lands and reduce the effects of climate changes. Bekret et al. (2015) reported in their study that beekeepers in the Kayseri region complained that nectar and pollen resources that bees can use to raise offspring are scarce, especially in the early spring months, and that in recent years, as an effect of global warming, the flowering and nectar secretion periods have changed and honey yield has decreased. In this respect, it has been stated that it has become a necessity for bee colonies to be fed with additional feeds with appropriate formulations in March and April in order to produce more offspring and enter the nectar flow more strongly.

Lack of sufficient nectar in the nectar source visited by honey bees is an important stress factor. In this case, it seems that cooperation between forager bees is aimed to reduce competition (Hranitz et al., 2009). In case of insufficient nectar and pollen sources, honey bees even self-destruct by sticking their heads into the honeycomb cells in order to preserve the limited food available for the next generation (Yücel, 2008).

In the study conducted to determine the habitat suitability of bumblebees, it is stated that environmental sensitivity and environmental factors should be determined in determining habitat suitability. It was reported that a conservation-oriented management planning should be made against climatic warming (Herrera et al., 2014). For the planning of food resources of bumblebees, 4 types of pollen and nectar mixtures and 6 types of wildflower mixtures were applied.

Solutions against the current global warming have been investigated through studies on the beginning and end of flowering, planning of new blooms and their breeding (Memmott et al., 2010). The effects of climate change on honeybee populations depend on specific life cycle characteristics and physiological adaptations. Early winter application to the Osmia lignaria bee, which needs a certain period of cold to complete the dormancy period, disrupted the development of the dormancy period, but did not have a negative effect on physical development. Therefore, in the global warming scenario, it has been stated that phenotypes with a long summer pause period, which effectively maintains the short pre-winter period despite the delayed arrival of winter, can replace the phenotypes with a short summer pause period (Sgolastra et al., 2011).

7.Conclusion

It is a fact that our country will be more affected by climate change due to intensive agricultural activities. Many fruit species currently grown are exposed to sudden heat and cold, and our farmers suffer financial losses. Precautions against climate change should be taken and the varieties to be grown should be well determined. For a mistake made in fruit growing, the effects of this mistake are paid for for many years. For sustainable fruit growing and profitability in production, there is a need for research aimed at meeting climate change and changing consumer preferences. In addition, since climate is one of the stress factors that directly affects the food resources needed by honeybees, intensive migratory beekeeping is used to get maximum efficiency from the flora. Sudden climate changes, if no precautions are taken, can lead to a decrease in resistance in weak colonies, an increase in disease and pest activity, and eventually the extinction of the colony. A good beekeeper must follow meteorological data and flora and take precautions. Farmers have to take some economical technical and cultural measures, considering meteorological events. For this reason, data on climate parameters is always needed in fruit growing and beekeeping and they are affected by climate change. Now agricultural production; It has become an activity carried out by fighting against the climate.

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REFERENCES

Akbulut, S., 2000. Küresel ısınmanın böcek populasyonları üzerine muhtemel etkileri. Ekoloji. 9(36): 25-27.

Aybak, H. Ç., 2000. Çilek Yetiştiriciliği. Hasat yayıncılık Ltd. Şti. s.118, İstanbul.

Banaszak, J. 1986. Impact of agricultural landscape structure on diversity and density of pollination insects. Les Colloques de l'INRA, 36: 75-84.

Barnuud, N.N., Zerihun, A., Mpelasoka, F., Gibberd, M., Bates, B., 2014. Responses of grape berry anthocyanin and titratable acidity to theprojected climate change across the Western Australian wine regions. International Journal of Biometeorology, 58(6): 1279-1293.

Bekret, A., Çankaya, S., Silici, S. 2015. The Effects of Mixture of Plant Extracts and Oils are Added to Syrup on HoneyBee ColonyDevelopment and Honey Yield. Turkish Journal of Agriculture-Food Science and Technology. 3(6)365-370.

Beppu, K.,Kataoka, I., 1999. High temperature rather than drought stress is responsible for the occurance of double pistil in 'Satohishiki' sweet cherry. Scientia Horticulture, 81:125-134.

Braun, P., Müller, M., 2012. Effects of Climate Change on Fruit Production in the State of Hesse. INKLIM Module II plus, Abstract of final report.

Campoy, J.A., Ruiz, D., Egea, J., 2011. Dormancy in temperate fruit treesin a global warming context: A Review. Scientia Horticulturae (Amst)130(2):357– 372.

Crane, E., 1972. Bees on the pollination of seedcrops. The Royal Agricultural Society of England, England, 119:133-135.

Darrow, G.M., 1966. The Strawberry. History, Breeding and Physiology. Holt, Rinehart and Winston, New York.

Doğan, S., Özçelik, S., Dolu, Ö., Erman, O. 2010. Küresel ısınma ve biyolojik çeşitlilik. İklim Değişikliği ve Çevre, 3: 63-88.

Engin,H., Ünal, A. 2004. Kirazlarda Çift Meyve Oluşumuna Su Eksikliğinin Etkileri.Ege Üniversitesi, Ziraat Fakültesi Dergisi, 41(2):19-28.

Erdoğan, Y., Dodoloğlu, A., & Zengin, H. (2004). Farklı çevre koşullarının bal kalitesi üzerine etkileri/Effect of different environmental conditions on honey quality. Atatürk Üniversitesi Ziraat Fakültesi Dergisi, 36(2), 157-162.

Erdoğan, Y., & Dodoloğlu, A. (2005). Balarısı (Apis mellifera L.) kolonilerin yaşamında polenin önemi. Uludağ Arıcılık Dergisi,5(2), 79-84.

Erdogan, Y., Dodologlu, A., & Emsen, B. (2009). Some physiological characteristics of honeybee (Apis mellifera L.) housed in heated, fan wooden and insulated beehives. Journal of Animal and Veterinary Advances, 8(8), 1516-1519.

Erdoğan, Y. (2019). Determination of the effect of electric fence system on productivity and behaviour of honeybees housed in different beehive types (Apis mellifera L.).Italian Journal of Animal Science,18(1), 941-948.

Farina, W.M., Grüter, C., Acosta, L., Mc Cabe, S., 2007. Honeybees learn floral odors while receiving nectar from foragers within the hive. Naturwissenschaften 94:55-60.

Fennell, A. 2014. Genomics and functional genomics of winter low temperature tolerance in temperate fruit crops. Critical Reviews in Plant Sciences. 33(2-3):125-140.

Fründ, J., Zieger, S.L., Tscharntke, T., 2013. Response diversity of wild bees to over wintering temperatures. Oecologia, 173(4):1639-1648.

Genç, F., Dodoloğlu, A. 2002. ArıcılığınTemel Esasları. Atatürk Üniv. Ziraat Fakültesi Yayınları, No:166, 338 s, Erzurum.

Giorgi, F., Lionello, P. 2008. Climate Change Projections for the Mediterranean Region. Global and Planetary Change. 63(2):90-104.

Goodwin, R.M, Congdon, N.M., 2018. Recognition and attractiveness of staminate and pistillate kiwifruit flowers (Actinidia deliciosa var. deliciosa) by honey bees (Apis mellifera L.). New Zealand Journal of Crop and Horticultural Science, 46: 72-80.

Guédon, Y., Legave, J.M., 2008. Analyzing the time-course variation of apple and pear tree dates of flowering stages in the global warming context. Ecological Modelling, 219(1):189-199.

Hatjina, F., Costa, C., Büchler, R., Uzunov, A., Drazic, M., Filipi, J., Kezic, N. 2014. Population dynamics of european honeybee genotypes under different environmental conditions. Journal of Apicultural Research, 53(2):233-247.

Hegland, S. J., Nielsen, A., Lázaro, A., Bjerknes, A. L., Totland, Q., 2009. How does climate warming affect plant-pollinator interactions? Ecology Letters, 12(2):184-195.

Herrera, J.M., Ploquin, E.F., Rodríguez-Pérez, J., Obeso, J.R., 2014. Determining habitat suitability for bumble bees in a mountain system: a baseline approach fo testing the impact of climate change on the occurrence and abundance of species. Journal of Biogeography, 41(4):700-712.

Hranitz, J.M., Barthell, J.F., Abramson, C.I., Brubaker, K.D., Wells, H., 2009. Stress protein responses in Honeybees: Is it useful to measure stres responses of individual bees in the hive? Uludag Bee Journal, 2:60-71.

İmrak, B., Küden, A., 2012. Bazı kiraz çeşitlerinin subtropik iklim koşullarındaki çoklu dişi organ oluşumu sorununun çözümüne ilişkinaraştırmalar. Çukurova Üniversitesi, Fen ve Mühendislik Bilimleri Dergisi, 28(5):62-71.

Karaman, M.R., 2018. Arı Polinasyonu. Küçükersan, M.K., Ed. Arıcılık, Arı Ürünleri ve Apiterapi. 1. Baskı. Ankara, Türkiye Klinikleri; 26-32.

Kekeçoğlu, M., Rasgele, P.G., Akıllı, M., Kambur, M., 2015. Sürdürülebilir Çevre İçin Arı Farkındalığı Yaratılmasında" Arı Biziz Bal Da Bizdedir" Projesinin Yeri. Uludag Bee Journal, 14(2):74-87.

Keller, M., 2010. Managing grapevines to optimise fruit development in a challenging environment: A climate change primer for viticulturists. Australian Journal of Grapeand Wine Research, 16(1):56-69.

Koç, A. U., Karacaoğlu, M. 2012. Kafkas (A. m. caucasica), İtalyan (A. m. ligustica) ırkları ve anadolu arısı ege ekotipi (A. m. anatoliaca) ile bazı melezlerinin ege bölgesi koşullarında koloni gelişimleri. TRALLEIS. 1(1):28-35.

Le Conte, Y., Navajas, M., 2008. Climate change: impacton honeybee populations and diseases. Revue scientifique et technique International Office of Epizootics, 27:485-97.

Lorenz, S., 2021. The socio diversity of biodiversity. Interdisciplinary communication and the example of honeybees. Ecosystems and People,17(1), 41-46.

Luedeling, E., Girvetz, E.H., Semenov, M.A., Brown, P.H., 2011. Climate change affects winter chill for temperate fruit and nuttrees.PLoSOne, 6(5), e20155.

McGregor, S.E., 1976. insect Pollination of Cultivated Crop Plants. Agriculture Handbook No: 496, 345-349.

Mel‶nichenko, A.N., 1977. Role of insect -pollinators in increasing yields of agricultural plants. In"Pollination of agricultural Crops by bees Vol. III,"ed, A.N.Mel‶nichenko, Amerind Publishing Co. Pvt. Ltd. New Delhi, Bombay, Calcutta, Nevyork, 150 pp.

Memmott, J., Carvell, C., Pywell, R.F., Craze, P.G. 2010. The potential impact of global warming on the efficacy of field margins sown forthe conservation of bumble-bees. Philosophical Transactions of the Royal Society B: Biological Sciences, 365(1549):2071-2079.

Michalský, M., Hooda, P.S., 2015. Greenhouse gas emissions of imported and locally produced fruit and vegetable commodities: A quantitative assessment. Environmental Science& Policy, 48:32-43.

Moore, J. N., 1964. Duratıon of receptıvıtyto pollınatıon of flowers of the hıgh -bush blueberry ve the cultıvated strawberry. American Society for Horticultural Science Proceedings, 85: 295-301.

Moretti, C.L., Mattos, L.M., Calbo, A.G., Sargent, S.A., 2010. Climate changes and potential impacts on post harvest quality of fruit and vegetable crops: A Review. Food Research International, 43(7):1824-1832.

Omoto Y., Aono Y., 1990. Estimationof Change İn Blooming Dates of Cherry Flowerby Urban Warming. Journal of Agricultural Meteorology, 46:123-129.

Ötleş, S., 1995. Bal ve Bal Teknolojisi (Kimyası ve Analizleri). Alaşehir MYO Yayınları No:2, Ege Üniversitesi Basımevi. s88, Bornova/İzmir.

Özbek, H., 1992. Balarısı (Apis mellifera L.)'nın bitkilerin tozlaşmasında kullanılması. Doğu Anadolu Bolgesi I. Arıcılık Semineri (3–4 Haziran 1992), 30-47, Erzurum.

Özçağıran, R. (2002). Çiçekli bitkilerde tozlanma ve çiçektozu taşıyıcıları. Ege Üniversitesi Ziraat Fakültesi Dergisi, 39(2)151-158.

Pope, K.S., Dose, V., Da Silva, D., Brown, P.H., DeJong, T.M. 2014. Nut Crop Yield Records Show That Budbreak-Based Chilling Requirements May

Not Reflect Yield Decline Chill Thre sholds. International Journal of Biometeorology, 59(6):707-715.

Quamme, H.A., Cannon, A.J., Neilsen, D., Caprio, J.M., Taylor, W.G., 2010. The potential impact of climate change on the occurrence of winter freeze events in six fruit crops grown in the Okanagan Valley. Canadian Journal of Plant Science. 90(1):85-93.

Rader, R., Reilly, J., Bartomeus, I., Winfree, R., 2013. Native bees buffer the negative impact of climate warming on honeybee pollinationof watermelon crops. Global Change Biology, 19(10):3103-3110

Sgolastra, F., Kemp, W.P., Buckner, J.S., Pitts-Singer, T.L., Maini, S., Bosch, J., 2011. The long summer: pre-wintering temperatures affect metabolic expenditure and winter survival in a solitary bee. Journal of Insect Physiology, 57(12):1651-1659.

Süzer, S., 2005. Çilek Yetişticiliği. http://www.ttae.gov.tr/makaleler/chilek.htm

Szenteleki, K., Ladányi, M., Gaál, M., Zanathy, G., Bisztray, G., 2012. Climatic risk factors of central hungarian grape growing regions.applied ecology and environmental research. 10(1):87-105.

Şahinler, N., 2000. Arı ürünleri ve insan sağlığı açısından önemi. Mustafa Kemal Üniversitesi Ziraat Fakültesi Dergisi, 5(1-2), 139-148.

Topal, E., Arda E, Karaca Ü, Kuşoğlu P. 2013. Bal arılarının tozlaşmaya katkıları. Hasad Bitkisel Üretim Dergisi, 339: 90-93.

Webb, L.B.,Whetton, P.H., Barlow, E.W.R., 2007. Modelled impact of future climate change on the phenology of wine grapes in Australia. Australian Journal of Grape and Wine Research. 13(3):165-175.

Yakar, N., Bilge, E., 1987. Genel Botanik. İstanbul Üniversitesi Fen Fakültesi Yayınları. Yayın No. 200, s 488. İstanbul.

Yakovleva, L. P., 1975. Utilization of bees for pollination of entomophilous farın crops in the USSR. Bulletın Technıque Apicole Opida 2 (SuP-.lement): 199~208.

Yücel, B. 2008. Çevresel Sorunların Bal Arıları Üzerine Etkileri. Hasad, 279:40-43.

Zakour M K, Bienefeld K. 2014. Basic considerations in the development of breeding plans for honey bees, illustrated by data on the native Syrian honey bee (Apis mellifera syriaca). Journal of Apicultural Research, 53(2), 314-326.

Zavalloni, C., Andresen, J.A., Winkler, J.A., Flore, J.A., Black, J.R., Beedy, T.L., 2004. The pileus project: climatic impact son sour cherry productionin the great lakes regionin past and projected future time frames. VII International Symposium on Modelling in Fruit Research and Orchard Management. 707:101-108.

CHAPTER 4

COMMON PROBLEMS IN BEEKEEPING AND SIMPLE SOLUTIONS TO THESE PROBLEMS

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1.INTRODUCTION

Honeybees are of vital importance in natural balance and agricultural production, as they produce products that are extremely valuable for human health and nutrition, and provide pollination for wild and cultivated plants.

Living all over the world except the poles, honey bees are social insects that play a major role in the ecological system, being the most important pollinators of flowering plants. (Amin, Nishat, Afroz, & Ghosh, 2019).

Beekeeping is a very old branch of agriculture that has been practiced since ancient times.

Products such as honey, beeswax, pollen, bee venom and royal jelly can be obtained from beekeeping and sold commercially. This helps increase the income level of producers and rural development. Beekeeping, which does not compete with other agricultural systems, is an important component of agricultural and rural development programs (Kaplan, 2008; Klein et al., 2007).

As a consequence, the maintenance of bees and beekeeping is highly significant for farmers and government officials. (Bencsik et al., 2015).

While carrying out beekeeping activities, beekeepers face some problems. It is very important to know these problems in advance and take the necessary precautions as soon as possible.

2.Swarming in Honeybees

Honeybees reproduce through colony division (swarming) (Figure 1). The first swarm normally contains the colony's old egg-laying queen, while subsequent swarms contain unmated queens.

Honeybee Colonies must reach a sufficient population size at the beginning of the season in order to reproduce.

Generally, each swarm consists of 50-60% of the adult bee population in the colony (Winston, 1987).

Although there are bees of all individuals and ages within the swarm, young worker bees are found in greater numbers (Muszynska, 1976; Winston, 1987).

Since swarming colonies produce less honey than non-swarming colonies, beekeepers implement various techniques to avoid colonies from swarming (Farrar, 1937).

Swarming typically occurs over a 4-6 week period in late spring to early summer, dependent on the climate and flora.

During swarming, thousands or sometimes tens of thousands of worker bees gorge on honey within the hive and gather into a buzzing cloud formation outside the hive. They then leave en masse and, within a few minutes, along with the queen, form a cluster resembling a bunch of grapes on a suitable tree, bush, or other location close to the hive.

Swarming honey bees tend to sting less as their abdomens are full of honey and they exhibit less defensive behavior when away from their brood and food stores. Therefore, honey bee swarming is usually not hazardous. The beekeeper is responsible for preventing the colony from swarming (Matsuzawa & Kohsaka, 2021; Melathopoulos, Rodia, Holt, & Sagili, 2018).

It is difficult to predict the exact location where a swarm will settle after leaving its hive. The swarm may temporarily rest in any suitable location, but will inevitably depart as soon as scout bees identify a safer and more suitable nesting spot. When housed in temporary accommodations, the swarm will typically form a cluster with the queen at its center, which plays a critical role in regulating temperature. The bees will remain clustered for hours or even days while the guide bees search for a new settlement. When a viable location is found, the bees will take off collectively and fly towards it.

Simple observations made in May and June can indicate the likelihood of colony swarming. It is important to note that these observations should be approached objectively and without biased language. Key indicators of this behavior include a scarcity of eggs in the combs, with more closed comb cells present instead. Additionally, queen cells may be located at the top or bottom of frames.

Figure 1. Swarm.

2.1. Prevention of Natural Swarm

In the case of natural swarming, the worker bee population is reduced, as about half of the colony leaves the hive, taking some of the honey from the hive. This in turn reduces the amount of honey that will be produced. This means that there will be no honey to harvest that season. It also means that the colony may find it difficult to survive the winter.

In areas with long winters, bee colonies are not able to recover from swarming, enter the winter strong and often die out in winter. Colonies with older queens are more prone to swarming.

It should not be forgotten that swarming is a normal event for honey bees and is their way of reproduction. However, it is a virtue that every beekeeper must know to give up the colony from this situation. Because swarming both decreases honey yield and increases wintering losses.

There are some common and effective methods to discourage bee colonies from swarming. Some of these methods are;

- To prevent the colony from becoming cramped, it is necessary to maintain a large inner volume in the hive. Because once the colony is focused on swarming, it is exceedingly challenging to deter them from doing so. To ensure adequate space, it is crucial to keep the hive volume ample.
- Before the nectar flow in spring, a queen excluder (Figure 2) should be placed over the brood box and honey super should be placed on it.

- The hive should be well-ventilated by keeping the ventilation holes open. It is important to ensure proper air circulation inside the hive.
- Small holes can be created at the front of the honey supers to enable the bees to enter and exit and facilitate proper ventilation. The holes must be of a size that enables the bees to fend off potential predators. The openings should be sealable in extremely cold weather.
- A clean water source should be provided close to the apiary.
- Prevent the sun from shining on the hives all day long. (canopy should be made).
- • Colonies must be checked every week and all queen cells, if any, must be destroyed immediately.
- The queen bee must be replaced every two years.
- If some of the brood frames in the brood supers and some of the beewax frames in the honey supers exchange places, the tendency to swarm will decrease.

Figure 2. Queenexcluder (https://thebeestore.com.au/blogs/bee-blog/what-is-a-queen-excluder).

2.2. If The Colony Swarm Despite All The Precautions Taken

Despite all the precautions taken, if the colony still swarm; If it is placed in an easy place close to the apiary, it can be shaken directly into an empty, clean hive with a sufficient number of frames inside it, without any extra precautions. If the swarm is placed on a high point, then it can be picked up with the swarm bag attached to the end of the pole.

The swarm is shaken into the empty bucket, a cover cloth is laid on it and the lid of the bucket is closed. It is kept in a shaded place until the evening and placed in its place in the apiary in the evening.

After the swarm, the following steps are followed.

One week after swarming, the queen status of the main colony should be checked.

It is unlikely that eggs will be seen in the comb cells a week after the swarm is removed; But it is too early to give a new queen bee. However, it would be good to check it to detect the queen bee. If it cannot be found, the colony is given another week and checked again.

After swarming, it will take six to eight days for the queen cells to open and the fertile queen to emerge.

After swarming, it will take six to eight days for the queen cells to open and the fertile queen to emerge.

The queen bee will go on a mating flight approximately 5 days after leaving the eye. She will start laying eggs 3-4 days after returning from the mating flight. In other words, the queen will start laying eggs approximately two weeks after the swarm emerges.

When there is a queen bee in the colony, the queen's chest should be painted with the color of the year (Table 1). This allows the queen bee to be easily found during subsequent checks and to determine its age. Oğuldan iki hafta sonra kovanı tekrar açılır ve petek gözlerinde yumurta aranır.

If there are eggs, there is no problem, it means the colony has a queen. If there is no queen bee, it should be removed immediately and a new queen bee should be introduced to the colony.

Otherwise, the colony will be left without a queen and will go to a false queen.

Table 1. Year color codes used to determine queen bee age.

GREEN	BLUE	WHİTE	YELLOW	RED
2024	2025	2026	2027	2028
2029	2030	2031	2032	2033
2034	2035	2036	2037	2038
2039	2040	2041	2042	2043

2.3. Taking the Swarm Into the Hive

- A suitable container (cardboard box, swarm bag, empty beehive) is placed under the swarm cluster.
- We hold the branch on which the swarm cluster is located, shake it quickly and make the cluster fall into the container. We keep the container stationary for a while and ensure that all the bees fill the container. We take this box and empty it into the prepared bucket.
- If the swarm lands on a thin branch, we cut the branch with pruning shears and remove the swarm without shaking him. We take it and gently shake it into the framed bucket we prepared before. When all the bees enter the hive, we slowly close the cover cloth.

2.4. Pushing The Swarm Into The Hive

- Decide where you want to place your new honeybee colony.
- At this location, create a clean new empty hive with honeycomb. The hive entrance hole must be fully open.
- A cloth is spread in front of the hive.
- The bees in the box are placed on the cloth as close to the entrance as possible (Figure 3).
- After a week, the hive is checked and the condition of the bees is seen.

Figure 3. take swarm by pushing method

3. Colony Abandoning the Hive

Abandoning occurs when the bee colony leaves the hive completely. There are many reasons for this, the most common are.

- Colony Collapse Disorder (CDD): It is a new phenomenon that has been seen very commonly around the world recently. The exact causes of this syndrome are not known.
- Not enough food in the hive. (When food deficiency reaches its extreme level, feeding with syrup should be done if it is available in the season).
- Loss of queen bee
- Unsuitable living conditions. (The hive should be positioned so that it is not too cold or too hot. The hive ventilation must be sufficient, the hive must be inclined forward to prevent moisture accumulation in the hive).
- Infestation of pests (hive beetles, ants and other insects) that negatively affects the internal conditions of the hive and especially disturbs weak colonies.
- Parasites such as Varroa and some bee diseases can cause the colony to abandon its hive.

4. Loss Of Queen Bee

Due to many reasons, the colony may be left without a queen. A colony without a queen is doomed to extinction. For this reason, a new queen bee should be given to the colony without delay. This can be done by two methods.

4.1.The Colony Should Be Ensured To Produce Its Own Queen.

When the colony loses its queen, they try to raise a new queen bee by turning the combs with worker cells into queen cells (figüre 4) from the daily eggs in the existing worker bee cells. The virgin queen bees emerging from the thimble go on a mating flight a few days later, mate with the male bees and return to the hive. A few days later, she starts laying eggs.

Figure 4. Queen bee cells.(https://www.queenandcolony.com/blog/2019/3/8/why-do-bees-swarm).

If there are no eggs daily, it is not possible for the colony to raise a queen bee. However, it should not be forgotten that queen rearing is a long process and takes at least a month. As a result, the honey production season is spent inefficiently. Therefore, it would be more logical to give an purchased queen bee.

4.2.Introducing A Queen Bee That You Have Produced Yourself Or Purchased From Outside To The Colony.

Advantages of giving ready queen bees to queenless colonies

- Queen bees are quickly introduced to queenless colonies.
- The queen bee is guaranteed to be fertile.
- The race and quality of the queen bee are determined.
- A frame without brood is removed from the brood super.
- All bees in this removed frame are shaken into the hive.
- The queen bee cage (Figure 5) is placed in a frame space formed in the middle of the brood supers, by opening the entrance hole of the part where the cake is placed, and by squeezing it between the frames at an inclination of approximately 45^{o}, with the dusty part facing the cover cloth.
- When placing the queen bee cage, make sure that the part where the cake is located is facing upwards.

Figure 5. Giving a new queen bee to a bee colony in a cage (https://www.honeyflow.com/blogs/beekeeping-basics/installing-a-queen-into-a-hive-split).

- After providing the queen bee cage, the colonies are given a period of one week and at the end of this period, the colony is examined.
- It is checked whether the queen bee is released or not. If the queen bee cannot leave the cage for any reason, the queen bee is removed from the cage and released into the hive.

5. Preventing The Brood From Getting Cold

In some regions, the weather is unstable and the temperature difference between day and night can be quite high. In the spring, when brood rearing is very intense, when the temperature drops excessively, bees may move into clusters, and the broods left outside may get cold. The young that get cold and die are removed from the brood by the worker bees and thrown out. This can be understood by the appearance of dead larvae on the flying board or in front of the hives. It is normal to have a small number of dead larvae in each colony. This should not cause beekeepers to panic

- When the temperature drops below 10C^{o}, maintenance and control of colonies should be kept very short.
- Adequate ventilation must be provided to prevent condensation of steam inside the hive.
- Control of colonies should be done on windless days (Harsh wind may cause the brood to get cold).

6. Robbing In Honeybee

Plundering is when worker bees of one hive steal honey from other hives. This is a very serious situation for several reasons.

- Trying to protect itself against plunder, the colony fights to the death. This war can cause the death of many bees or even the extinction of the colony.
- If the hive cannot defend itself in case of plunder, the army that does not plunder will plunder all the food of the colony.
- Bees in the attacked colony become angry, worn out and become very difficult to control.

6.1. Understanding Whether The Density In Front Of The Hive Is A Normal Situation Or Whether It Is Looting

During heavy nectar flow there can be a lot of activity at the entrance of the hive. This is normal behavior of foraging bees.

Bees that go to collect food leave the hive flight hole quickly and intensively and return to the hive heavy with pollen and honey. When they return at noon, they crash into the hive flight board and stop. Sometimes they fall to the ground before reaching the hive and crawl towards it.

Again, great chaos occurs during the reconnaissance flights of worker bees. In this case, worker bees fly in front of the hive with their heads turned towards the hive. They fly intensely, as if suspended in the air. However, these bees do not have the irritability and aggression like the bees that come to plunder.

6.2. Robbing Bee Behaviours

- Robber bees approach the hive without being burdened with nectar or pollen. They do not head directly to the flight hole, but fly around the hive, looking for a weak entry point to enter.
- You can see bees fighting in front of the hive (Figure 6). These are guard bees trying to protect the hive. This is a sure sign of plunder.
- In case of plundering, the hive flight hole should be narrowed so that a single bee can pass through, in order to stop the plundering without delay. This facilitates the defense of the colony, but it should be taken into consideration that the hive will not ventilate well in hot weather since the flight hole is narrowed.
- A sheet is wetted and covered over the looted hive. Since the sheet reaches all the way to the ground, it is difficult for marauding bees to enter the hive. The sheet should be wetted as

it dries. After two days, the sheet is removed and the looting is over.

Figure 6. Marauding honey bees (https://beeinformed.org/2020/01/15/what-robbing-looks-like/)

6.3. Some Of The Practices That Can Be Done To Prevent Looting

- Honey and sweet substances should not be left in open areas where bees can find them.
- The honeycombs should be kept covered during harvest.
- While feeding the colonies with sugar syrup, not even a single drop should be spilled around.
- The flight hole should be narrowed until the colony becomes strong enough to defend itself.
- Open feeding should never be done.
- Boardman systems used for feeding from the flight hole should not be used.

Figure 7. Open feeding of bee (colonies.https://www.youtube.com/watch?app=desktop&v=IhsbCf4nCMk)

7. Formation of False Queen Bees in Honeybee Colonies

If the colony loses its queen bee for any reason and cannot raise a new queen, a false queen situation occurs.

Without the effect of queen pheromones that prevent the development of the worker bees' ovaries, the worker bees' ovaries develop and they gain the ability to lay eggs. Thus, the false queen situation occurs.

False queen bees can lay eggs, but these eggs are weak and infertile. So the male bee develops. If it is not detected in time, there will be no worker bees left to collect nectar and pollen in the colony. The colony disappears.

7.1. How to understand that a false queen has developed in the colony?

- There is no queen bee during the checks.
- The presence of drones in the colony much higher than normal. A normal colony contains several hundred drones.

- The presence of more than one egg in each of the comb cells in the incubation is an indication of a false queen bee. Because the real queen bee lays a single egg in each eye.

7. 2. How to get rid of false queen bees

Introducing a new queen bee to a colony that has become estranged does not solve the problem. Because the liar colony does not accept the new queen bee and kills it.

In order to produce a new queen bee, all false queen bees must be destroyed. Since these are worker bees, it is very difficult to tell them apart. However, when the appropriate method is used, achieving results is guaranteed.

A new queen bee is supplied in advance.

The false queen hive is placed on a wheelbarrow and taken to a minimum distance of 100 meters from the apiary.

- Shake off all the bees on the frames to the ground.
- Fill the shaken frames into the empty hatchery, take them at least 20-30 meters away from the point where you shook them and close the lid.
- It is ensured that not a single bee remains on these frames.
- Return the frames to the hive's old location in the apiary and transfer them into the original hive. Close and shake the cover cloth and wait for the worker bees who did not lay eggs to return to the hive. Since egg-laying worker bees do not leave the hive for a long time, they forget the location of the hive and cannot return to the hive.
- When the hive is returned to its old place, some bees will be encountered there. These are field bees. Not lying mothers. When placing the hive, care should be taken not to crush them.
- New queen bees can now be given to worker bees returning to the hive. Since these colonies will need young worker bees, it would be appropriate to supplement these hives with closed brood frames.

8. Protection of Bee Colonies from Pesticide Harms

“carrier of diseases that may occur in humans or animals; In order to prevent, destroy or control any pests that may negatively affect these practices during the production, processing, transportation, storage and/or marketing of foods, agricultural products, wood and wood products or animal feed, or to control pests that may be present on animals or their bodies. are the substances used.”(FAO, 2003).

oday, 8% of the pesticides used in agricultural control are fipronils, 80% are neonicotinoids, 8% are carbamates, 2% are pyrethroids, and 3% are OF. (Yalçın & Turgut, 2016).

8.1. Symptoms Of Pesticide Poisoning İn Honeybees;

- Dead worker bees piled up at the hive entrance.
- Stress and aggression in bees.
- Bees make angry and loud sounds.
- Bees appear crawling in front of the hive.
- The tongue of dead bees extends outwards.
- As a result of intense poisoning, the queen bee only lays eggs, thus the colony disappears. (Ergün & Altıntaş, 2022).

Honeybees are greatly affected, especially when pesticides are unconsciously applied to fruits and vegetables during the day (Figure 8). When we look in front of the hive, we see a lot of dead bees on the ground. This creates a tragic situation for both the bee and the beekeeper.

8.2. What To Do To Prevent Honeybees From Being Poisoned By Pesticides

- Neighboring farmers should be informed about the days they sprayed pesticides.
- Spraying should be done in the evening, not during the day.
- On the day of spraying, a wet cloth that extends to the ground is covered over the hive. It is removed the next day.
- On the day of spraying, the hive flight hole can be closed (for a day).

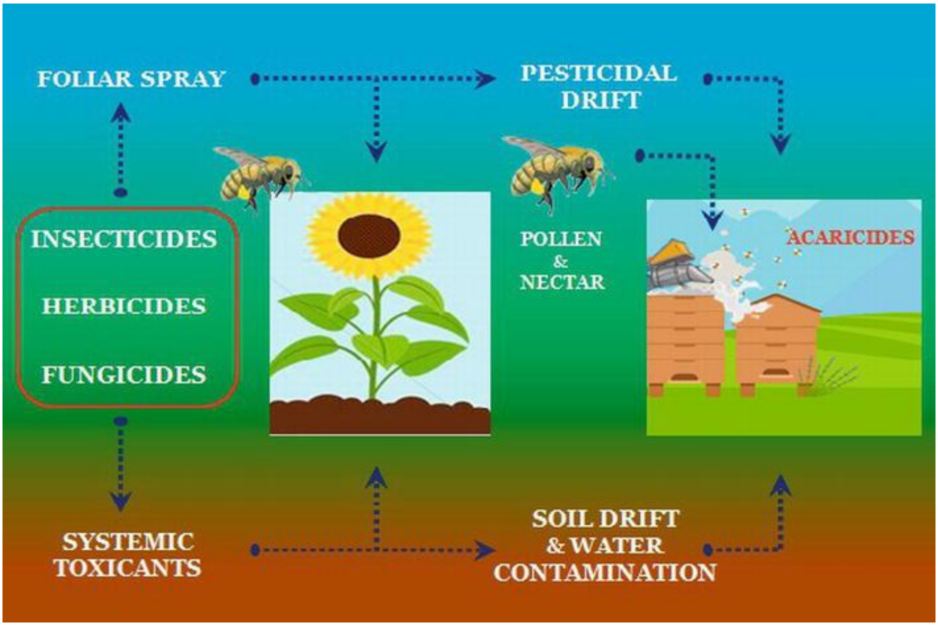

Figure 8. Pesticide poisoning in honey bees from various sources. (https://www.intechopen.com/chapters/71161)

REFERENCES

Amin, M., Nishat, M., Afroz, M., & Ghosh, P. J. B. J. o. E. (2019). Apiculture for sustainable agriculture: Bangladesh perspective. 1(1), 47-52.

Bencsik, M., Le Conte, Y., Reyes, M., Pioz, M., Whittaker, D., Crauser, D., . . . Newton, M. I. J. P. o. (2015). Honeybee colony vibrational measurements to highlight the brood cycle. 10(11), e0141926.

Ergün, H., & Altıntaş, L. J. V. F. v. T. D. B. (2022). PESTİSİTLERİN ARI YETİŞTİRİCİLİĞİNE ETKİSİ. 13(1), 26-46.

FAO. (2003). International Code of Conduct on the Distribution and Use of Pesticides. In: FAO Rome.

Farrar, C. J. J. a. R. (1937). The influence of colony populations on honey production. 54(12), 945-954.

Kaplan, J. K. J. A. R. (2008). Colony collapse disorder: a complex buzz. 56(5), 8.

Klein, A.-M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., & Tscharntke, T. J. P. o. t. r. s. B. b. s. (2007). Importance of pollinators in changing landscapes for world crops. 274(1608), 303-313.

Matsuzawa, T., & Kohsaka, R. J. E. (2021). Status and trends of urban beekeeping regulations: A global review. 2(4), 933-942.

Melathopoulos, A., Rodia, M., Holt, J., & Sagili, R. R. (2018). Residential Beekeeping: Best-practice guidelines for nuisance-free beekeeping in Oregon: Oregon State University Extension Service.

Muszynska, J. J. P. Z. N. (1976). Porównanie pszczól z roju i macierzaka. 1976.

Winston, M. L. (1987). The biology of the honey bee: harvard university press.

Yalçın, M., & Turgut, C. J. J. o. A. M. U., Agricultural Faculty. (2016). Bal Arılarında Koloni Kaybı. 13(1), 2.

CHAPTER 5

ROYAL JELLY IN TERMS OF ITS STRUCTURAL AND FUNCTIONAL PROPERTIES

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1. INTRODUCTION

Royal jelly is secreted from the hypopharyngeal gland of young worker bees, sometimes called the brood gland, to feed the adult queen bee and young larvae. Queen bees and larvae are fed directly with royal jelly as it is secreted, without being stored. Therefore, royal jelly is not a traditional beekeeping product. The larva, which has been previously determined to be raised as a queen bee, can be harvested when it is fed with plenty of royal jelly. The queen larva cannot consume food as quickly as it is deposited into the queen cell. The difference between queen and worker bees is related to feeding during the larval stages. Indeed, a queen bee can be produced from all female eggs (Genç and Cengiz 2019, Önk at all 2016). However, this occurs during the full development of the larva, especially in the first four days, and these larvae are fed and cared for like a queen bee. Queen rearing is regulated by complex mechanisms within the hive. The changes that occur in a young larva through a series of hormonal and biochemical effects and reactions enable the development of a queen bee. A queen bee differs from a worker bee in several aspects: In its morphology, while organs related to pollen baskets, strong jaws, brood feeding glands and wax glands develop in the worker bee, reproductive organs develop in the queen bee. During the Development Period, while the worker bee requires 21 days for development, the queen bee develops in an average of 15.5 days. While the worker bee lives for a few months, the queen bee lives for a few years. In its behavior, the worker bee only rarely lays eggs, while the queen bee lays several thousand eggs a day. Unlike workers, the queen bee does not participate in general hive activities. In fact, it is believed that the queen bee's longevity and extraordinary productivity will produce similar effects in humans, as it is fed exclusively with royal jelly. In the early 1950s, French beekeeping publications began to appear praising the properties of royal jelly, based on research conducted in several hospitals.

The royal jelly phenomenon began with surprising biological facts on the one hand, and with commercial speculation based on initial results obtained by entomologists and physiologists on the other, exploiting the imagination of consumers eager to be convinced by this unknown and rare product. In fact, royal jelly was so rare and little known that it was impossible to find this appeal in many products. In the following years, royal jelly quickly became known and consumed by large masses. Increasing demands motivated experts to develop new production techniques, and many beekeepers spent more time specializing in this activity.

At the same time, research was conducted on the quality control and biological and clinical properties of the commercial product. Consumption of royal jelly has increased day by day, even though its contribution to human health has not been scientifically proven. Western medical establishments have always been skeptical of the effects claimed for this product, although they do not accept that it was initially widely promoted in an attempt to deplete it. Although there are praising publications and partly abundant bibliography about the benefits of royal jelly, there is still a serious lack of scientific data on the clinical effects of royal jelly.

2. Properties of Royal Jelly

Royal jelly is a homogeneous substance, although it is quite fluid and has a dough structure. It has a slightly beige and yellowish-whitish color, a sharp phenolic odor and a characteristic sour taste. Its density is approximately 1.1 g/cm3 and it is partially soluble in water. Its viscosity varies with water content and time. It slowly becomes more viscous when kept at room temperature or refrigerated at 5°C. The increase in viscosity is associated with the increase in water-insoluble nitrogenous compounds, together with the reduction in free amino acids and soluble nitrogen. These changes are partly attributed to the interaction between lipids and protein fractions and sustained enzymatic activities. If sucrose is added to royal jelly, it becomes more fluid. Such changes in viscosity are associated with phenomena that regulate caste differentiation in the bee colony. Debris such as larval coat pieces found in royal jelly indicate its purity. Candle residues may also be encountered to a greater or lesser extent. But their existence depends significantly on the method of collection. Small particles may frequently form in stored royal jelly due to the precipitation of the compounds in it.

3. Structure of Royal Jelly

There have been numerous publications about the chemical analysis of royal jelly for years. Only in recent years, thanks to superior technologies, the complexity of its acidic structure (pH 3.6-4.2) and detailed analyzes of its special structure have been given. The main structures of royal jelly are water, protein, sugars, oils and mineral salts. Although there are changes in its structure (Table 1), the bee race remains relatively constant when harvest time and different colonies are compared (Cengiz 2021).

2/3 of fresh royal jelly is water. However, the most important part of its dry weight consists of proteins and sugars. There are six large proteins and four glycoproteins at an average level of 73.9% of nitrogenous substances. Free amino acids from nitrogenous structures are on average 2.3% and peptides are 0.16%. There are all amino acids that are essential for humans and all 29 amino acids and their derivatives. The most important ones are aspartic acid and glutamic acid. Proline and lysine are free amino acids. There are several enzymes, including glucose oxidase, phosphatase, and cholinesterase.

Sugars consist mostly of fructose and glucose in similar and fixed proportions as in honey. Fructose is more. For many reasons, fructose and glucose together make up 90% of total sugars. Sucrose content varies significantly from one sample to another. Other sugars found in lesser amounts are maltose, trihalose, melibiose, ribose and erlose.

Lipid content is a very interesting feature of royal jelly. The lipid fraction constitutes 80-90% of free fatty acids with their special and general structures. Lipids consist mostly of short-chain hydroxy fatty acids or dicarboxylic acids (with 8-10 carbon atoms), as opposed to the fatty acids with 14-20 carbon atoms commonly found in animals and plants. These fatty acids are responsible for many of the reported biological properties of royal jelly. The major acid is 10 hydroxy-2-deconoic acid, occurring at approximately 1.9%, followed by its saturated equivalent, 10 hydroxydeconoic acid. In addition to free fatty acids, lipid fractions include some neutral lipids, sterols (including cholesterol), and unsaponifiable fractions of hydrocarbons similar to wax extracts.

The total ash content of royal jelly is 1% of its fresh weight or 2-3% of its dry weight. The most abundant minerals are Ca, Na, Zn, Fe, Cu and Mn, although K is the most common.

Vitamin content is currently the subject of numerous studies. In the first research study, royal jelly was shown to be extremely rich in vitamins. Table 2 gives information about water-soluble vitamins. Only traces of Vitamin C were found. Initially, it was thought that royal jelly containing Vitamin E gave the queen bee reproductive efficiency, and this efficiency was associated with fat-soluble vitamins. But studies have shown that this is not the case. It also contains vitamins A, D and K.

contents	**Minimum**	**maximum**
Water	%60	%70
*Proteins (N*6.25)*	17% of dry weight	45% of dry weight
Carbohydrates	18% of dry weight	52% of dry weight
Lipids	3.5% of dry weight	19% of dry weight
Minerals	2% of dry weight	3% of dry weight

Table 1. Structure of Royal Jelly

During the initial studies, important findings were revealed regarding the search for sex hormones in royal jelly. The lack of gonadotropic effect in female rats clearly demonstrated the absence of any sex hormones. It has been shown to contain extremely small amounts of the hormone (0.012 µg/g wet weight) by very sensitive radioimmunological methods. On the other hand, a man produces 250,000-1,000,000 times more of this hormone per day than the amount found in 1 g of fresh royal jelly. No biological effect can be observed with such a small amount. Numerous compounds belonging to different chemical classes have been found in royal jelly. Biopterin and neopterin, two heterocyclic substances, are present in royal jelly as 25 and 5 µg/g by wet weight, respectively. These compounds are found in the worker bee larvae food at a concentration of approximately 1/10. Substances containing several nucleotides such as free bases (adenosine, uridine, guanosine, iridine and cytidine), phosphatases AMP, ADP and ATP, acetylcholine (1 mg/g dry weight) and gluconic acid (0.6% wet weight) have also been identified.

In all popular and scientific literature, there is a fraction of royal jelly described as “other, as yet unknown”. This statement not only highlights incomplete analytical information about the product, but also demonstrates our lack of understanding of the biological activities of royal jelly. Despite many studies to date, most of these activities have not been definitively proven and have not been linked to any known compounds.

4. Physiological Effect of Royal Jelly on Honey Bees

The effect of royal jelly as a food on honey bee larvae has been clearly known since it was described as an impressive biological phenomenon. Wonder drugs such as penicillin, hormones, and vitamins, which were popular in the 1950s, were newly discovered in the medical field and were seen as simple answers to many biological questions. The difficult-to-understand hormonal effect of royal jelly on honey bee larvae has led to the belief that it may have a similar miraculous effect on humans as honey bee larvae. Hormonal effects are not only responsible for the difference between worker and queen bees. However, the enormous fertility of the queen bee, which is genetically equal to the worker bee, is also distinctive because it apparently eats only that food. The long lifespan of the queen bee is unique among adult insects. Still, it is known that royal jelly is necessary for the vitality and productivity of the queen bee, but it is not known which fraction of it is essential and the minimum and maximum requirements of this component for the queen bee. Almost all attention is focused on the incomplete stages of development. Numerous studies have been carried out to discover the powers of hormones and other substances, to determine changes in requirements and to obtain top quality queen bees. Indeed, initial studies lead to the belief that a queen determinant exists and that it is an extremely unstable substance. This is such an unstable substance that it becomes ineffective within a day after it is secreted. All components of royal jelly were tested in studies conducted to identify the queen bee marker. At the end of the 1980s, the mystery was still unsolved, and some researchers proposed a different mechanism in which different proportions of nutrients are formed in the diet of worker and queen bee larvae. The higher larval food sugar content in young queen larvae causes differences among queen bees.(Cengiz at all, 2022a, Cengiz at all, 2022b)

5. Composition of Royal Jelly

5.1. Humidity

The most important element that constitutes the main compound of royal jelly is 60-70% moisture. While proteins, carbohydrates and lipids constitute the basic structure of the dry matter, minerals and vitamins also participate in the content of the dry matter.

5.2. Proteins and Peptides

Proteins and peptides constitute approximately 30% of the dry weight of royal jelly. Approximately 55-65% of these substances are soluble in water. In addition, there are also free amino acids in the L-series, which correspond to approximately 1-1.5% of the total protein structure. The most important of these amino acids are proline and lysine amino acids. When stored at room temperature, proline and lysine amino acid levels may increase over time due to proteolytic enzyme activity.

5.3. Lipids

Lipids, which have the highest ratio (3-19%) after protein in dry matter weight, consist largely of free fatty acids, and the remaining part is neutral oils, hydrocarbons and sterols. Most of the organic acids found in royal jelly are found in free form, and these organic acids are unusual substances that are rarely found in nature. As examples of these, we can give dicarboxylic acids with 8-10 carbons and mono- and di-hydroxy acids. The identification of these organic acids can be an indicator of the originality of royal jelly. Especially the use of 10-hydroxy-2-decenoic (HDA) acid in the authenticity test of royal jelly has been accepted. In addition, many fatty acids found in royal jelly have antibacterial functions, which provides a more hygienic environment.

5.4.Carbohydrates

Although the bee cycle consists of large amounts of fructose, glucose and sucrose, the trace portion also contains melibiose, trehalose, maltose, erlose and ribose. Its carbohydrate content makes royal jelly a high-energy food.

5.5.Minerals

Minerals (ash content) constitute 1-3% of the royal jelly content. The elements in this ash content consist of Na, Al, Zn, K, S, Cu, P, Mn, Fe, Ca and Mg, and there are trace amounts of Ni, Sn, Cr, Ti, Bi and Sb.

5.6.Vitamins

The vitamin content of royal jelly consists of riboflavin, niacin, folic acid and thiamine, and smaller amounts of biotin, pantothenic acid, inositol and pyridoxine. On the other hand, there are traces of vitamin C, but not vitamins A, D, E, K.

	Thiamin	Riboflavin	Pantothenic Acid	Pridoksin	Niasin	Folik Acid	Inositol	Biotin
Minimum	1.44	5	159	1	48	0.13	80	1.10
Maximum	6.70	25	265	48	88	0.53	350	19.80

Table 2. Vitamin content in fresh royal jelly (µg/g)

5.7.Other Small Components

When we look at the other components in royal jelly, in addition to heterocyclic substances such as biopterin and neopterin, substances such as free bases (uridine, adenosine, guanosine, iridine and cytidine), phosphate compounds, citric acid, lactic acid, malic acid, benzoic acid, gluconic acid and acetylcholine. is present in trace amounts.

6.Functional Properties

Royal jelly stands out with its therapeutic effect. Although some studies suggest that royal jelly can be injected, the healthiest method is to take it orally.

6.1. Antibacterial, Antiviral And Fungicidal Effects

Many studies have been conducted to explain the antibacterial properties of royal jelly, and as a result of these studies, it has been reported that it has an inhibitory effect especially on gram-positive bacteria and gram-negative bacteria. It is known that various proteins and peptides and HDA contained in royal jelly show activity against many types of bacteria. Additionally, royal jelly is recommended to inhibit many antibiotic-resistant bacteria such as Pseudomonas aeruginosa.

6.2.Bio-Stimulating And Antiaging Activity

It is observed that royal jelly triggers the growth processes of bee larvae and accelerates the metabolism in bee colony development. It has been observed that royal jelly increases weight gain in various animals when given alongside bee larvae, and it has been determined that it causes an increase in the amount of oxygen carried to tissues and metabolic activities. These effects were explained by the oxidative phosphorylation process and increased respiration. It has been noticed in various human tissue and cell studies that it has a cell life-extending effect.

6.3. Immuno-Modulating Effects

Royal jelly has activating or activity-terminating effects on immunomodulatory factors and especially affects the alpha globulin fraction. It induces the formation of T-lymphocytes, which control the body's immune response against viruses and cancer cases. It has also been observed that royal jelly inhibits the metastasis effect and also has an anti-inflammatory effect.

6.4. Effects On The Nervous System

An increase in the central nervous system phosphorylation process and cholinesterase enzyme activity was observed in mice given royal jelly. In addition, in studies given at high doses, it has been observed that it causes structural changes in nerve neurons. The cAMP-N1 oxide compound, which is not found in any other substance other than royal jelly, directly affects neuronal change and triggers the formation of different brain cells. However, it also facilitates the differentiation of various brain cells such as neurons, astrocytes and oligodendrocytes.

It is thought to have an effect on suppressing neuronal decline and increasing neurogenesis in Parkinson's and Alzheimer's diseases, and studies on this are ongoing.

6.5. Cardiovascular Effects

It has been explained that royal jelly affects different blood parameters such as serum cholesterol and triglyceride, causing a decrease in plasma fibrinogen levels and an increase in high-density lipoprotein-cholesterol levels. Royal jelly is recommended as a heart protector as a result of various studies and has positive effects on adrenaline-induced myocarditis.

6.6. Other Effects

Its liver-protective, radiation-protective effects, anti-oxidative effects, preventing insulin resistance, preventing osteoporosis and supporting bone formation, supporting collagen formation and suppressing atopic dermatitis-like skin lesions have been reported.

6.7. Chronic toxicity

Although various toxicity studies on royal jelly are ongoing, clear toxicity information cannot be expressed. In some cases, it shows toxic properties at low doses, but does not show any toxic properties at high doses. More studies are needed on this subject.

6.8. Allergy

In recent years, there is a lot of information that royal jelly causes allergic reactions. Although these data come from East Asian countries where royal jelly is consumed more, data obtained from European countries also show that allergic reactions caused by royal jelly occur less frequently. It is recommended that people with a history of allergies and asthma have an allergy test before consuming royal jelly and be cautious against bronchial spasms and anaphylactic shock. It has been stated that extra care should be taken for pregnant or breastfeeding women and young children.

7.Conclusion

Royal jelly is a bee product that is secreted by young worker bees from their hypopharyngeal glands, sometimes called brood feeding glands, to feed the adult queen bee and young larvae, with a high moisture content and rich in carbohydrates, lipids, minerals and vitamins, containing large amounts of proteins, peptides. Royal jelly is very effective in the development of honey bee larvae and has an important place in the healthy nutrition of humans and other animals. Royal jelly is a unique bee product that makes a significant contribution to the development of the nervous system and cardiovascular system, as well as making great contributions in terms of its antibacterial properties, anti-aging effects, biocompatibility and immune-supporting properties. However, more studies are needed on its toxic properties and caution should be taken in case it causes allergic reactions.

With all this, royal jelly is a product whose content is still not fully clarified, but we recommend its consumption by having allergic reaction tests done due to its extraordinary effects on living systems.

REFERENCES

Akbay, R., 1995. Arı ve İpek Böceği Yetiştirme. Ankara Üniversitesi Ziraat Fakültesi. Yayın No : 1428.

Anonymous, 1993. A Study on Relationship Between Number of Queen Cells and Yield and Quality of Royal Jelly. China Popular Science Press. p. 92-103.

Cengiz, M. M., Diler, A. & Yazıcı, K. (2022a). Structural Status of Beekeepers and Beekeeping Enterprises in Ardahan. Arı ve Arıcılık Teknolojileri Dergisi, 1(1), 19-28.

Cengiz, M. M., Diler, A., Ürüşan, H. (2022b). Ergin Bal Arılarının Beslenmesi. Y. ERDOĞAN, Y. Y. YILMAZ (Ed.), Arı ve Arıcılık (196-214. ss.), İksad Yayınevi, Ankara.

Cengiz, M. M., 2021. Bal Arısı (Apis mellifera L.) Kolonilerinde Muhtemel Kışlama Kayıpları Sebepleri ve Stratejik Öneriler. Tarım Ve Hayvancılık Üzerine Bilimsel Çalışmalar (121-150 ss), İksad Yayınevi, Ankara.

Fuhai, L., Fuxiu, L., Shengming, H., Shibi, C., 1993. Study on the Relationship Between Royal Jelly Yield and Supplementary Feeding. China Popular Science Press. p. 131-144.

Genç, F., & Cengiz, M. M. (2019). Bal Arısı (Apis mellifera L.) Anatomisi, Genetik ve Islahı ile Ana Arı Yetiştiriciliği. Gece Kitaplığı, Ankara, 203.

Gül, M. A., Kaftanoğlu, O., 1986. Çukurova Bölgesi Koşullarında Ana Arı Yetiştiriciliğinde Uygulanan Larva Transfer Yöntemlerinin Yetiştirilen Ana Arıların Kalitelerine Olan Etkilerinin Üzerinde Bir Araştırma. ÇÜ. Fen ve Müh. Bil. Der. 4(2):41-53.

Jianke, L., Weitua, Y., 1995. Interrelationship Between Number of Queen Cells and Royal Jelly Quantity and Quality. Apimondia Zhengzhou Animal Huzbandry Engineerng Collage Zhengzhou. China.

Ji-kai, S., 1993. Relationship of Jelly Collection Circle and Instar of Larvae to Royal Jelly Yield. China Popular Science Press. p. 145-150.

Kaftanoğlu, O., Kumova, U., Yeninar, H., 1992. Ana ArıYetiştiriciliğinin Önemi ve Ana Arı Kalitesini Etkileyen Faktörler. Doğu Anadolu Bölgesi I. Arıcılık Semineri. 3-4 Haziran 1992. s. 48-60.

Krell, R., 1996. Value-Added Products from Beekeeping. FAOAgricultural Services Bulletin No. 124

Laidlaw, H. H., 1979. Contemporary Queen Rearing. Dadant and Sons. Hamilton. Illinois.

Önk, K., Cengiz, M. M., & Kırmızıbayrak, T. (2016). Kafkas Irkı (Apis mellifera caucasica) Ana Arılarının Bazı Üreme Özellikleri Üzerine Yetiştirme Dönemlerinin Etkisi. Atatürk Üniversitesi Veteriner Bilimleri Dergisi.

Öztürk, C., 1995. Balarısı (Apis mellifera L.) Kolonilerinden Elde Edilen Arı Sütünün Önemi, Üretim Tekniği, Saklanması ve Kullanım Olanakları. ÇÜ. Fen Bilimleri Enstitüsü. Zootekni Anabilim Dalı. Bölüm İçi Seminerleri.

Öztürk, C., Kumova, U., 1998. Çukurova Koşullarında Balarısı (Apis mellifera L.) Kolonilerine Uygulanacak Farklı Besleme ve Yetiştirme Yöntemlerinin Arı Sütü Verimine Olan Etkilerinin Araştırılması. Teknik Arıcılık Dergisi. Sayı :59.

Root, A. I., 1978. ABC and XYZ of Bee Culture. The A. I. Root Company. Medina. Ohio. USA.

Salow, M. H., 1985. Some Affecting Factors on the Royal Jelly Production. Mosul Univ. (Iraq). Coll. Of Agriculturer and Foresty. p.147.

Shengming, H., Shibi, C., Fuhai, L., Fuxiu, L., 1991. Relationship Between Temprature and Storage Jelly Amount in the Queen Cell on Royal Jelly Frame. China Popular Science Press. p. 112-125.

Shibi, C., 1993. The Technique of Upgrading the Output and Quality of Royal Jelly. . China Popular Science Press. p. 1-6.

Shibi, C., Shengming, H., Fuhai, L., Fuxiu, L., 1993 a. Study on the Relationship Between the Yield and Quality of Royal Jelly and the Age of Grafted Larvae. China Popular Science Press. p. 67-81.

Shibi, C., Shengming, H., Fuhai, L., Fuxiu, L., 1993 b. Study on the Correlation of the Age of Nurse Bee with Royal Jelly Yield and Quality. China Popular Science Press. p. 82-91.

Tolon, B., 1996. Arı Ürünleri Standartlarının Üretim ve İhracat Açısından İrdelenmesi. Hayvancılık'96 Ulusal Kongresi. 18-20 Eylül 1996. İzmir.

TSE, 1989. Türk Standartları. Arı Sütü. TS 6666. Türk Standartları Enstitüsü

Witherell, 1984. Other Products of the Hive. Edited by Dadant and Sons. Hamilton. Illinois.

CHAPTER 6

NUTRIENT COMMUNICATION IN HONEY BEES

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1. INTRODUCTION

Honey bee colonies consist of thousands of larvae, pupae, worker bees, hundreds of drones, and queens. The queen and drones are responsible for mating. The queen bee performs the task of laying eggs (Rangel et al., 2013). After the worker bees emerge from the comb cells, they begin a duty that starts with cleaning, brood rearing, and queen care. The worker bees then continue to build honeycombs, prepare and store nutrients, then defend the colony, and search for nutrients and propolis (Kolmes, 1985; Winston, 1987). These duties of worker bees are not entirely dependent on age (Rothenbuhler and Page, 1989). The duties of worker bees are also affected by elements like environmental circumstances, genetic factors, colony requirements, juvenile hormones, and food accessibility (Seeley, 1998; Sullivan et al., 2000; Page and Kerr, 2019). Pheromones, trophallactic interactions, the transfer of nutrients from one bee to another and the language of dance are other factors that ensure the continuity and functioning of the colony (Farina and Nunez, 1993; Biesmeijer and Seeley, 2005; Bortolotti and Costa, 2014).

Adequate nutrition of honey bees is necessary for the continuity of the colony. Ensuring proper nutrition is linked to the nutrient composition. Inadequate nutrition causes many negative factors to occur and causes the colony to weaken or disappear. While many stress sources such as unfavourable environmental conditions, climatic changes, diseases, bee pests, pesticides and insufficiency of food resources are already affecting honey bees negatively, the stress level in honey bees increases even more with inadequate nutrition, and it becomes hard for them to fight with stress sources. A lack of proper nutrition results in a compromised immune system for honey bees, diminishing their capacity to combat diseases and pests, ultimately leading to losses in the colony (Cengiz et al., 2022).

The nutrient needs of incubating honey bees and adult honey bees are provided by nectar and pollen (Nicolson and Human, 2008). The activities of plants limit the food-gathering capacity of honey bee colonies. Since honey bees are dependent on plants for nutrition, they are significantly affected by adverse environmental conditions (Seeley, 1994). There is substantial variation in both the pollen and nectar characteristics among different plant species and among individual members of the same species. There are many nectar plants in the world. These plants are categorized as floral and extrafloral (Chatt et al., 2021). These plants have a structure that can attract honey bees and facilitate their access to nectar. The richness of nectar sources varies depending on environmental factors (Nicolson, 2007). Pollen quantity and quality exhibit significant variation among different plants as well. Even though some plants are poor in terms of nectar quality and quantity, they can attract the attention of honey bees because they are rich in pollen. Honey bees take into account the physical structure and odor of pollen grains when selecting pollen (Erdoğan and Dodoloğlu, 2005). While honey bee dances convey details about the nature and location of food sources, honey bees demonstrate flexibility in their selection of flowers. Forager bees tend to collect more nectar and choose one type of flower. As a result of this tendency, called floral fidelity, honeybees will continue to utilize the same flower species until the nectar and pollen supply is exhausted (Chittka et al., 1999).

Exploring for food sources is a distinctive behavior exhibited by honey bees. This behavior is notably affected by environmental conditions, as well as intracolony and extracolony factors, and numerous studies have been undertaken to explore this phenomenon. Foraging behavior provides great benefits to colonies and plant pollination (Young et al., 2007).

Food gathering is carried out by worker bees in harmony with each other in line with the colony's needs. There is a hierarchical order for food-gathering activities (Anderson et al., 2001). Having gained all the experience by completing their in-hive tasks, worker bees can finally collect food for the hive, usually at 21 days. Once the worker bees transition to the role of forager bees, they transport pollen, nectar, water, and propolis to the colony throughout their entire lifespan. During periods of abundant nectar availability, worker bees may engage in foraging activities even before reaching the age of 21 days (Winston, 1987; Huang and Robinson 1996). Generally, foraging skills and the number of foraging workers increase with age. Bees can also perform age-inappropriate duties, behaving according to changing conditions (Dukas and Visscher, 1994).

The foraging behavior, whether for pollen or nectar, is a trait at the colony level that has a genetic component and is shaped by the genotype of the bee lineage (Page et al., 1995; Rüppel et al., 2002). Past encounters at a food source contribute to the dynamics of collective foraging (Gil and Farina, 2002). The colony-level food-gathering activity is influenced by factors such as the abundance of food sources, the communication of information about food sources within the colony, the number of guide bees discovering the source, and the allocation of tasks to forager bees (Schulz et al., 1998). Sucrose response thresholds constitute another crucial factor determining the type of foraging duties (Scheiner et al., 2004).

The orchestration of labor division in foraging behavior and the transition of forager bees have been colony factors affecting, increased expression of the foraging, and/or heightened mRNA levels in the bee brain. (Whitfield et al., 2003). The shift of worker bees from in-hive responsibilities to outside-hive assignments is influenced by several factors. It has been proposed that the heightened juvenile hormone titer in bees plays a role in initiating foraging (Elekonich et al., 2001). The heightened concentration of octopamine in the antennal lobes of the bee brain is considered significant in the age-related division of labor. Octopamine is at higher levels in forager bees than in keeper bees (Schulz and Robinson, 1999; Schulz et al., 2002). It was additionally disclosed that changes in octopamine levels are regulated by juvenile hormone. (Mott and Breed, 2012). It has been found that increased vitellogenin level also causes a delay in food-seeking behavior (Nunes et al., 2013).

Forager bees are divided into two groups: bees that search for the best food source and give information about this food source by dancing, and bees that wait until these bees return to the hive (Nest and Moore 2012).

2. Nutrient Communication

Effective communication holds great significance in social insects. It organizes the colony's distribution of duties and allows them to use their workforce effectively (Seeley, 1989). In the communication system, the honey bee that receives the news responds physiologically to the stimulus generated by the honey bee that sends the information (Menzel et al., 2012). Two opinions exist on how honey bees determine the distance to food sources. One method involves estimating the distance flown in relation to energy consumption, while the other relies on in-flight observations (Esch et al., 1994).

Foraging honeybees face numerous navigational challenges that require cognitive skills to locate and return to essential locations, such as flower patches or the hive, which can be several kilometers away. Honeybees use different mechanisms, such as the solar compass, integrating the distance traveled, and recognizing familiar visual cues, to navigate with precision. During a foraging trip, honeybees exhibit distinct behavioral modules that change flight speed, straightness, and attitude. Depending on the bees' motivational state, these modules can enhance visual learning or facilitate location recall, whether to return home with a total harvest or to search for food (Doussot et al., 2024).

Honeybees use a communication system known as the 'bee dance,' discovered by Austrian scientist Karl von Frisch. This dance allows honey bees to convey information to one another within the hive (Frisch, 1993). Bee dance refers to the set of behaviors performed by worker bees who bring nectar and pollen to the hive to communicate with other worker bees and guide them. But honey bees do not only communicate in this way. Honey bees, which generally communicate with each other through pheromones, perform the bee dance mostly when they discover food sources or favorable nest conditions (Waddington, 1982; Frisch, 1993; Seeley, 1994).

The foundation of the bee dance lies in the necessity for collaboration among individuals as an essential aspect of social life in bee colonies. The bee dance enables honey bees to expend less energy and conserve time in collecting food. This conduct facilitates a significantly more efficient production process for the colony's nutrition (Liang et al., 2012).

Round dance or waggle dance may involve sensory methods of transmitting information. In honeybees, it is believed that the five sensory systems play a role in dance communication. It has been suggested that the development of dance language communication may be related to modifying central nervous system pathways associated with honey bees' ability to calculate distance and directional information during flight (Seeley, 1994; Brockmann and Robinson, 2007). The sound signals produced by dancing honeybees carry information about the whereabouts of food sources. Honeybees can perceive these close-range sounds and depend on them to interpret the messages conveyed through dance language. Dance sound is characterized by rhythmic air particle movement with high-velocity amplitude. The study investigating which sensory structures honey bees use to detect sound signals revealed that the Johnson organ is used (Dreller ve Kirchner, 1993).

In this system, often referred to as the waggle dance, forager bees that discover a food source communicate flight information, direction, and distance to other bees through specific movements (Michener, 1974). The type and number of dances contain information about the distance and quantity of the food source. The emergence and persistence of movements in dance depends on both external (e.g., the nutritional status of the colony and the abundance of food resources) and internal stimuli (e.g., the dancer's level of nutrition and experience of foraging for food resources (Seeley and Pagano, 2000). Foragers incorporate cues from nest mates to assess the nutritional state of the colony, subsequently adjusting their waggle dance activity accordingly (Tautz, 1996).

The round dance within the waggle dance allows the colony to reach food sources over short distances. The round dance is short and contains some directional information about the source. Although information about the distance is given in this form of communication, the direction and location are not clear. This active behavior changes based on the distance between the hive and the food source, such as an elevated directional spread during consecutive swinging runs over shorter distances and enthusiastic walking circles for nearer flowering regions (Waddington and Kirchner, 1992).

If the food source is more than 100 meters away, the waggle dance is used; if it is closer than 100 meters, the round dance is used. These dances can be used with slight variations to identify sources of pollen, nectar, water and propolis. The round dance is performed on a honeycomb in a narrow space. The bee dancing the dance occasionally changes position and is followed by 1-6 honey bees. At distances of up to 100 meters, the circular dance is a declaration of food sources, performed in a semicircle to the left and to the right. The other honeybees imitate the dance by watching the honeybee performing the dance carefully (Dyer, 2002). Bees watching the dance sometimes touch the dancing bee with their antennae to identify the source type. In one study it was reported that the follower bees had intense an antennal contact with the dancer bee. At least one spatial parameter of the contact pattern can inform the follower about their position in relation to the dancer, lead the follower to the back end of the dancer, and enable the follower to learn about the location of the food source advertised by the dance (Rohrseitz and Tautz, 1999).

The waggle dance communicates distance and direction. In the dance, the bee runs for a short distance, then turns to the right and makes a semicircle, then flies a semicircle on the same line, this time to the left. At the same time, the honey bee shakes or vibrates its abdomen (Frisch, 1993). In the wagging phase, as the bees following the drone follow the dancer from behind and to the sides, changes in air flows and electrostatic field occur with the wing flapping and wagging movements produced by the dancer. The frequency of the movements performed tells the distance of the source from the hive (Gould and Towne, 1987). The flicker indicates that the source is more than 100 meters away. If the food source is 200 meters away, the honey bee waves its abdomen left and right ten times in 15 seconds. The bee performs three dances in 15 seconds for 300 meters. If the distance is 1000 meters away, it waves five times in 15 seconds; for a distance of 2000 meters, it makes 3,5 circles on average. The waving of the abdomen and the speed at which the circles are formed are proportional to the richness of the food source (Frisch, 1993). The liveliness in dance expresses the richness of the source (Seeley and Pagano, 2000).

In the dance, which includes waving movements, the honey bee describes in detail the position of the hive in relation to the sun by creating different angles. The forager bees leaving the hive take advantage of the angle of the sun to the hive to return to the hive. When hives are relocated, honey bees have difficulty locating them when they want to return to the hive. The specialized eye structure of honey bees allows them to detect the direction of sunlight even in overcast weather. Detailed information about the food source is given by describing its position in relation to the sun. The forager bee utilizes the angles of the sun and the food source concerning the hive to convey the food location information to other bees. The angles correspond to the sections in the semicircles performed during the dance. If the source is on a line between the sun and the hive, the direction of the center line in the semicircles in the dance is in the full-up position. Differences in the dance can also vary based on the position between the sun and the hive. In the dance performed for a source located in the direction of the sun, the honeybee dances with its head up. For the source that is opposite the direction of the sun, the honey bee dances with its head down. (Dyer, 1985; Dyer, 1987; Frisch, 1993).

In addition to dancing, honey bees also provide food source information to the bees in the colony through their odor glands. It is thought that the pheromones left by the bees on the route during their return to the colony are effective in finding the food source (Srinivasan et al.,2000).

Honeybees also decide whether to utilize the food source and whether to gather more bees in this area by assessing the sugar concentration in the food source. Other bees evaluate the information transmitted through the dance language. This evaluation includes the quality of the resource, the colony's needs, and other factors. When a collective decision is made, a consensus is formed among the bees in the colony. If the resource is considered valuable enough, it is decided to send more bees to find and collect it. Typically, this decision is based on a combination of the energy level of the bee performing the dance and the perceived value of the resource. As a result of collective decisions, other bees within the colony can be directed to use the resource more effectively. This involves sending more bees to visit a particular resource. The capacity to promptly adapt to fluctuations in the characteristics and amount of food resources enhances the overall productivity of the colony. A flexible foraging strategy gives colonies an advantage in adapting to environmental changes. (Scheiner et al, 2004).

Forager bees require nocturnal sleep, and sleep deprivation can impact the orientation memory of honey bees. Research has shown that sleep-deprived bees have reduced precision in their waggle dances, with negative effects on the orientation of their dances (Beyaert et al., 2012). Inaccuracy in a bee's performance of a waggle dance can result in impaired information transfer and consequently reduced foraging efficiency for vital resources (Klein et al., 2010).

The dance executed by a honeybee that has successfully located a food source upon its return to the nest imparts information regarding the presence, scent, direction, quality, and distance of the specific food source. This communication allows her nest mates to effectively assess the source and reach it.

REFERENCES

Anderson, C., Franks, N. R., & McShea, D. W. (2001). The complexity and hierarchical structure of tasks in insect societies. Animal Behaviour, 62(4), 643-651.

Beyaert, L., Greggers, U., & Menzel, R. (2012). Honeybees consolidate navigation memory during sleep. Journal of Experimental Biology, 215(22), 3981-3988.

Biesmeijer, J. C., & Seeley, T. D. (2005). The use of waggle dance information by honey bees throughout their foraging careers. Behavioral Ecology and Sociobiology, 59, 133-142.

Bortolotti, L., & Costa, C. (2014). Chemical communication in the honey bee society. Neurobiology of chemical communication.

Brockmann, A., & Robinson, G. E. (2007). Central projections of sensory systems involved in honey bee dance language communication. Brain Behavior and Evolution, 70(2), 125-136.

Cengiz, M. M., Diler, A., & Ürüşan, H. (2022). Ergin Bal Arılarının Beslenmesi. Y. Erdoğan, Y. Y. Yılmaz (Ed.), Arı ve Arıcılık (196-214. ss.), İksad Yayınevi, Ankara.

Chatt, E. C., Mahalim, S. N., Mohd-Fadzil, N. A., Roy, R., Klinkenberg, P. M., Horner, H. T., ... & Nikolau, B. J. (2021). Nectar biosynthesis is conserved among floral and extrafloral nectaries. Plant physiology, 185(4), 1595-1616.

Chittka, L., Thomson, J. D., & Waser, N. M. (1999). Flower constancy, insect psychology, and plant evolution. Naturwissenschaften, 86, 361-377.

Crailsheim, K. 1998: Trophallactic interactions in the adult honeybee (Apis melliferaL.). Apidologie29,97–112.

Doussot, C., Purdy, J., & Lihoreau, M. (2024). Navigation: Cognition, learning, and memory. In The Foraging Behavior of the Honey Bee (Apis Mellifera, L.) (pp. 85-104). Academic Press.

Dreller, C., & Kirchner, W. H. (1993). Hearing in honeybees: localization of the auditory sense organ. Journal of Comparative Physiology A, 173, 275-279.

Dukas, R., & Visscher, P. K. (1994). Lifetime learning by foraging honey bees. Animal behaviour, 48(5), 1007-1012.

Dyer, F. C. (1985). Mechanisms of dance orientation in the Asian honey bee Apis florea L. Journal of Comparative Physiology A, 157(2), 183-198.

Dyer, F. C. (1987). Memory and sun compensation by honey bees. Journal of Comparative Physiology A, 160(5), 621-633.

Dyer, F. C. (2002). The biology of the dance language. Annual review of entomology, 47(1), 917-949.

Elekonich, M. M., Schulz, D. J., Bloch, G., & Robinson, G. E. (2001). Juvenile hormone levels in honey bee (Apis mellifera L.) foragers: foraging experience and diurnal variation. Journal of Insect Physiology, 47(10), 1119-1125.

Erdoğan, Y., & Dodoloğlu, A. (2005). Balarısı (Apis mellifera L.) kolonilerin yaşamında polenin önemi. Uludağ Arıcılık Dergisi, 5(2), 79-84.

Esch, H., Goller, F., & Burns, J. E. (1994). Honeybee waggle dances: the “energy hypothesis” and thermoregulatory behavior of foragers. Journal of Comparative Physiology B, 163, 621-625.

Farina, W. M., & Núñez, J. A. (1993). Trophallaxis in honey bees: transfer delay and daily modulation. Animal behaviour, 45(6), 1227-1231.

Frisch, K. V. (1993). The dance language and orientation of bees. Harvard University Press.

George, E. A., & Brockmann, A. (2019). Social modulation of individual differences in dance communication in honey bees. Behavioral Ecology and Sociobiology, 73, 1-14.

Gil, M., & Farina, W. (2002). Foraging reactivation in the honeybee Apis mellifera L.: factors affecting the return to known nectar sources. Naturwissenschaften, 89, 322-325.

Gould, J. L., & Towne, W. F. (1987). Evolution of the dance language. The American Naturalist, 130(3), 317-338.

Huang, Z. Y., & Robinson, G. E. (1996). Regulation of honey bee division of labor by colony age demography. Behavioral Ecology and Sociobiology, 39, 147-158.

Klein, B. A., Klein, A., Wray, M. K., Mueller, U. G., & Seeley, T. D. (2010). Sleep deprivation impairs precision of waggle dance signaling in honey bees. Proceedings of the National Academy of Sciences, 107(52), 22705-22709.

Kolmes, S. A. (1985). A quantitative study of the division of labour among worker honey bees. Zeitschrift für Tierpsychologie, 68(4), 287-302.

Leoncini, I., Le Conte, Y., Costagliola, G., Plettner, E., Toth, A. L., Wang, M., ... & Robinson, G. E. (2004). Regulation of behavioral maturation by a primer pheromone produced by adult worker honey bees. Proceedings of the National Academy of Sciences, 101(50), 17559-17564.

Liang, Z. S., Nguyen, T., Mattila, H. R., Rodriguez-Zas, S. L., Seeley, T. D., & Robinson, G. E. (2012). Molecular determinants of scouting behavior in honey bees. Science, 335(6073), 1225-1228.

Menzel, R., Fuchs, J., Kirbach, A., Lehmann, K., & Greggers, U. (2012). Navigation and communication in honey bees. Honeybee Neurobiology and Behavior: A Tribute to Randolf Menzel, 103-116.

Michener, C. D. (1974). The social behavior of the bees: a comparative study. Harvard University Press.

Mott, C. M., & Breed, M. D. (2012). Insulin modifies honeybee worker behavior. Insects, 3(4), 1084-1092.

Nicolson, S. W., & Human, H. (2008). Bees get a head start on honey production. Biology letters, 4(3), 299-301.

Nicolson, S. W., Nepi, M., & Pacini, E. (Eds.). (2007). Nectaries and nectar (Vol. 4). Dordrecht: Springer.

Nunes, F. M., Ihle, K. E., Mutti, N. S., Simões, Z. L., & Amdam, G. V. (2013). The gene vitellogenin affects microRNA regulation in honey bee (Apis mellifera) fat body and brain. Journal of Experimental Biology, 216(19), 3724-3732.

Page Jr, R. E., Waddington, K. D., Hunt, G. J., & Fondrk, M. K. (1995). Genetic determinants of honey bee foraging behaviour. Animal Behaviour, 50(6), 1617-1625.

Page, R. E., & Kerr, W. E. (2019). Honey bee genetics and breeding. In The African honey bee (pp. 157-186). CRC Press.

Rangel, J.; Keller, J.J.; Tarpy, D.R., 2013. The effects of honey bee (Apis mellifera L.) queen reproductive potential on colony growth. Insect Soc., 60: 65–73.

Rohrseitz, K., & Tautz, J. (1999). Honey bee dance communication: waggle run direction coded in antennal contacts?. Journal of Comparative Physiology A, 184, 463-470.

Rothenbuhler, W. C., & Page Jr, R. E. (1989). Genetic variability for temporal polyethism in colonies consisting of similarly-aged worker honey bees. Apidologie, 20(5), 433-437.

Rüppell, O., Pankiw, T., & Page Jr, R. E. (2004). Pleiotropy, epistasis and new QTL: the genetic architecture of honey bee foraging behavior. Journal of heredity, 95(6), 481-491.

Scheiner, R., Page, R. E., & Erber, J. (2004). Sucrose responsiveness and behavioral plasticity in honey bees (Apis mellifera). Apidologie, 35(2), 133-142.

Schulz, D. J., Barron, A. B., & Robinson, G. E. (2002). A role for octopamine in honey bee division of labor. Brain behavior and evolution, 60(6), 350-359.

Schulz, D. J., Huang, Z. Y., & Robinson, G. E. (1998). Effects of colony food shortage on behavioral development in honey bees. Behavioral Ecology and Sociobiology, 42, 295-303.

Seeley, T. D. (1989). The honey bee colony as a superorganism. American Scientist, 77(6), 546-553.

Seeley, T. D. (1994). Honey bee foragers as sensory units of their colonies. Behavioral Ecology and Sociobiology, 34, 51-62.

Seeley, T. D. (1998). Thoughts on information and integration in honey bee colonies. Apidologie, 29(1-2), 67-80.

Seeley, T. D., Mikheyev, A. S., & Pagano, G. J. (2000). Dancing bees tune both duration and rate of waggle-run production in relation to nectar-source profitability. Journal of Comparative Physiology A, 186, 813-819.

Srinivasan, M. V., Zhang, S., Altwein, M., & Tautz, J. (2000). Honeybee navigation: nature and calibration of the" odometer". Science, 287(5454), 851-853.

Sullivan, J. P., Jassim, O., Fahrbach, S. E., & Robinson, G. E. (2000). Juvenile hormone paces behavioral development in the adult worker honey bee. Hormones and behavior, 37(1), 1-14.

Tackenberg, M. C., Giannoni-Guzmán, M. A., Sanchez-Perez, E., Doll, C. A., Agosto-Rivera, J. L., Broadie, K., ... & McMahon, D. G. (2020). Neonicotinoids disrupt circadian rhythms and sleep in honey bees. Scientific reports, 10(1), 17929.

Tautz, J. (1996). Honeybee waggle dance: recruitment success depends on the dance floor. Journal of Experimental Biology, 199(6), 1375-1381.

Tezze, A. A., & Farina, W. M. (1999). Trophallaxis in the honeybee, Apis mellifera: the interaction between viscosity and sucrose concentration of the transferred solution. Animal behaviour, 57(6), 1319-1326.

Van Nest, B. N., & Moore, D. (2012). Energetically optimal foraging strategy is emergent property of time-keeping behavior in honey bees. Behavioral Ecology, 23(3), 649-658.

Waddington, K. D. (1982). Honey bee foraging profitability and round dance correlates. Journal of comparative physiology, 148(3), 297-301.

Waddington, K. D., & Kirchner, W. H. (1992). Acoustical and behavioral correlates of profitability of food sources in honey bee round dances. Ethology, 92(1), 1-6.

Whitfield, C. W., Cziko, A. M., & Robinson, G. E. (2003). Gene expression profiles in the brain predict behavior in individual honey bees. Science, 302(5643), 296-299.

Winston, M.L., (1987). The Biology of the Honey Bee. Harvard University Press: London, UK.

Young, H. J., Dunning, D. W., & von Hasseln, K. W. (2007). Foraging behavior affects pollen removal and deposition in Impatiens capensis (Balsaminaceae). American Journal of Botany, 94(7), 1267-1271.

CHAPTER 7

EXAMINATION OF HONEY IN TERMS OF ITS STRUCTURE, TYPES, IMPORTANCE FOR HUMAN HEALTH AND FOOD SAFETY

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1. INTRODUCTION

Turkey has a great beekeeping potential with its suitable ecology, rich flora, approximately 8 million colonies, 110 thousand tons of honey production, and 15 kg honey yield per colony. Beekeeping in our country has increased in recent years in terms of the number of beehives and has reached the top of the world rankings. The fact that the plant flora in Turkey is very rich provides this rise. Of the more than 300,000 plant species in the world, approximately 12,000 (Avcı, 2005) species are found in Turkey and most of them are endemic plants. Different honeys are produced in different regions of our country depending on their flora. The most important among these are; plateau, chestnut, citrus, clover, sunflower, cotton, corn, acacia and linden honeys (Genç, 1994; Gül and Şahinler, 2004; Şahinler et al., 2004 and 2003; Anonymous, 2005). In addition to this rich variety of flower honey, secretion (pine) honey is also produced in Muğla and its surroundings in our country. Although pine honey is produced in limited amounts in a few countries other than our country in the world, the country where the most pine honey is produced is Turkey (Sunay et al., 2003). These produced honeys are consumed domestically and also exported abroad. However, there have been serious problems in exporting abroad in recent years. As a result of the strict biochemical controls carried out by the European Union, non-standard criteria, drug and metal residues are detected in most of the exported honey and the honey is sent back (Şahinler et al., 2003).

2. Description And Structure Of Honey

According to the honey communiqué, honey; “It is the sweet substance that honey bees, after collecting flower nectar and secretions of plants or some living creatures living on plants, modify by mixing with their own substances and store in honeycombs.” It is defined as (Anonymous, 1990). Nectar, which greatly affects the physical and chemical properties of honey, also directly affects honey quality. Nectar may contain between 30-70% water. For this reason, the nectar should be moturation and the water content should be reduced to around 17-18% (Grandi et al., 1980; Sönmez and Altan, 1992). Otherwise, honey's high moisture content causes it to ferment in a short time.

Production season, plant origin and climatic conditions affect the structure of honey. The most important factor among these is the plant type (Crane, 1975; Yaniv and Rudich, 1996; Şahinler et al., 2004; Toy and Şahinler, 2022). The basic composition of honey is carbohydrates. 85-95% of carbohydrates consist of glucose and fructose. There are also sugars such as sucrose, maltose, isomaltose, mestitose and lactose. In addition to carbohydrates, the structure of honey contains organic acids, amino acids (lysine, histidine, arginine, aspartic acid, serine, glutamic acid, proline, glycine, alanine, valine, methionine, leucine, isoleucine, triosine, phenylalanine, tryptophan), mineral substances (potassium, sodium, calcium, magnesium, iron, copper, manganese, chlorine, phosphorus, sulfur, sulfur dioxide, iodine), vitamins (riboflavin, pantothenic acid, niacin, thiamine, pyridoxine, ascorbic acid), enzymes (amylase, sucrose, invertase, phosphotase, catalase, glucose oxidase) and flavoring substances (Crane, 1975; Yaniv and Rudich, 1996; Sunay et al. 2003; Şahinler et al., 2004). These components are the most important components that affect the quality of honey and they show the quality of honey. Mineral content determines the botanical origin of honey. For example, flower honey contains less mineral substances than secretion honey (Vorwohl et al, 1989). Storage of honey for a long time causes an increase in invert sugar content (White et al, 1961), and an increase in acidity in honey leads to fermentation of honey. In addition, it is desired that the amount of HMF (Hydroxy Methyl Furfural) is low in quality honey. Post-harvest heating, storage time, storage temperature and pH of honey affect the increase in the amount of HMF in honey. Storage and heating of honey for a long time also affects diastase activity, which is one of the important quality criteria in honey (Şahinler and Gül, 2004; Şahinler, 2007; Toy and Şahinler 2022).

Fluidity, chemical composition, sugars, moisture, enzymes, vitamins, acids, colloidal substances and substances of unknown composition in honey vary depending on the origin (Rosenblat, 1997; Albay, 2003; Şahinler et al., 2004; Gül and Şahinler, 2004; Şahinler and Gül, 2005; Toy and Şahinler 2022).

Table 1. Compositions of flower and secretion honeys Ingredients Flower honey Secretion honey

Component	Flower Honey			Honeydew Honey		
	Average	Min.	Max.	Average	Min.	Max.
moisture (%)	17.2	13.4	22.9	16.3	12.2	18.2
Fructose (%)	38.19	27.25	44.26	31.80	23.91	38.12
Glucose (%)	31.28	22.03	40.75	26.08	19.23	31.86
Sucrose(%)	1.31	0.25	7.57	0.80	0.44	1.14
Maltose (%)	7.31	2.74	15.98	8.80	5.11	12.48
Poly saccaharide (%)	1.50	0.13	8.49	4.70	1.28	11.50
Lactone	3.91	3.42	6.10	4.45	3.90	4.88
Free acidty	22.03	6.75	47.19	49.07	30.29	66.02
Lactone	7.11	0	18.76	5.80	0.36	14.09
Total acidity	29.12	8.68	59.49	54.88	34.62	76.49
Ash (%)	0.169	0.02	1.028	0.73	0.212	1.185
Nitrogen (%)	0.041	0	0.133	0.1	0.047	0.223
Diastasis	20.8	2.1	61.2	31.9	6.7	48.4
Unknown substance (%)	3.1	0	13.2	10.1	2.7	22.4

Crane, 1975

3. According To Honeys Sources

- Flower honey; It is honey produced by bees collecting the nectar secreted by nectar glands, usually found in the flowers of plants and sometimes in the petioles and stems of plants such as cherries, broad beans, cotton and peaches.
- Secretion honey; Honey is produced by bees collecting the sweet secretions secreted by insects living on forest trees such as pine, oak,

beech and spruce. The most important secretion honey for our country is pine honey (Genç, 1993).

4. Types Of Honey Produced İn Turkey

A wide variety of honey is produced in our country, depending on the rich flora. The most important among these are plateau, pine, chestnut, citrus, clover, sunflower, cotton, acacia and linden honey.

The honey plants that constitute the source of honey produced in our country are red clover, white clover, clover, sage, thyme, cornflower, astragalus, viper herb, mullein, scabies, black pepper, plum herb, sage, chicory, honeydew, sainfoin, lavender. , loveflower, mint and vetch are species that grow spontaneously in nature. Honey trees are acacia, linden, eucalyptus, pine, heather, various fruit trees (orange, lemon, almond, loquat), willow, false acacia, maple, blackberry, chestnut, berry, puree and judas tree. These plants and trees constitute a source of honey depending on their density in the region. Chestnut, linden, pine, acacia, puree, citrus, sunflower, thyme, cotton, highland and sage are important honeys widely produced in Turkey.

5. The İmportance Of Honey For Human Health

Honey is mainly used as a nutrient and energy source; In addition, it is important for human health and is used in the treatment of various diseases (Schmidt, 1997;Şahinler,1993). With this antibacterial feature, it is also used against mouth, throat and bronchial infections (Krell, 1996; Toy and Şahinler, 2022).

The healing effect of honey on the stomach and intestines is accepted by most people today. It is used effectively for the treatment of chronic digestive system diseases, especially peptic ulcer and indigestion (Al Somai et al., 1994; Schmidt, 1997; Molan, 1997), duodenal ulcer, and bacterial gastroenteritis in children (Haffejeei and Moosa 1985; Şahinler). ,1993;Toy and Şahinler,2022).

Honey is also used in the treatment of wounds and burns (Postmes et al., 1997); For example, creams and antibiotics used in the treatment of wounds and burns create scars and scabs, and with the use of honey, these negative effects are eliminated and healing occurs in a shorter period of time (Schmidt, 1997). In addition, it is used as a skin nourishing and moisturizing cream (Hutton, 1996; Armon, 1980; Dumronglert 1983). It is also stated that honey obtained from honey bee colonies fed with medicinal plant extracts is used against laryngitis, upper respiratory tract infections, chronic ulcers and wounds (Rosenblat et al., 1997). In clinical studies, it is reported that it is used against cataract disease, conjunctivitis and various corneal disorders by applying it directly into the eye (Krell, 1996;Şahinler, 1993).

Honey, which has regulating kidney functions, relieving insomnia and antipyretic effects, is used against heart, circulatory system diseases and liver disorders. It has been reported that the general condition improves after 20-40% honey water solution is injected into convalescent patients (Krell, 1996).

It is reported that honey also has antifungal activity, but this activity has not been tested against many fungal species. In addition, successful results are obtained by using honey against mastitis in cattle, goats and dairy animals (Molan, 1997). In recent years, it has been reported that honey has been used in the treatment of traumatological diseases (Feraboli, 1997).

The antioxidant properties of honey are due to compounds such as ascorbic acid, a-tocopherols, b-carotenes, as well as many polyphenolic compounds in its structure. Many phenolic compounds are identified in honeys of different botanical origins (Frankel et al. 1998). Additionally, a correlation was found between the antioxidant activity of honey and its proline content. It has been determined that some honeys containing high amounts of pyrroline amino acids have higher antioxidant capacity than other honeys (Meda et al. 2005).

Due to the many biological activities (antioxidant, antiradical, antibacterial, antiviral, anti-inflammatory, antitumoral, etc.) exhibited by various secondary metabolites contained in approximately 1% of its content, honey is used in an increasing number of applications, from the treatment of wounds to upper respiratory tract infections, from aging to the prevention of cancer formation. It is a natural food ingredient responsible for many phytobiological activities.

The use of honey in the field of apitherapy is preferred in the treatment or prevention of many diseases.

6. Examination Of Honey For Food Safety

Honey, which is a food substance with high nutritional value, is used in supportive treatment against various diseases as well as being used as a food substance. For this reason, the honey produced must comply with quality standards and not contain drug residues. This can be achieved by raising awareness and training of producers. Parameters related to honey quality standards are given in Table 3. Producing honey that complies with standards is important for food safety. The most important biochemical properties taken into consideration in the world honey trade are the HMF content of honey and the number of diastases in honey. These two biochemical properties are affected by the heating process applied to honey; honey exposed to heat at high temperatures loses enzymes, HMF content increases and the number of diastase decreases. HMF content is maximum 40 mg kg-1 according to TSE and EU standards, and 80 mg kg-1 according to CODEX standard; The number of diastases must be at least 8 in TSE, EU and CODEX standards.

Table 3: Turkish Food Codex Honey Standard (2013)

Quality Criterion	TSE	CODEX	UN
Mineral matter (%)	< 0.6 (flower honey) <1.0(honeydew honey)	< 0.6 (flower honey) < 1.0 (honeydew honey)	< 0.6 (flower honey) < 1.2 (honeydew honey)
Moisture (%)	< 21g/100g	< 21g/100g	< 21g/100g
Acidity (meq kg–1)	< 40 meq kg-1 (flower honey) < 40 meq kg-1 (honeydew honey)	< 50 meq kg-1 (flower honey) < 50 meq kg-1 (honeydew honey)	< 40 meq kg-1 (flower honey) < 40 meq kg-1 (honeydew honey)
HMF (mg kg–1)	< 40 mg kg-1(flower honey) < 40 mg kg-1 (honeydew honey)	< 80 mg kg-1 (flower honey) < 80 mg kg-1 (honeydew honey)	< 40 mg kg-1 (flower honey) < 40 mg kg-1 (honeydew honey)
Diastas number	> 8 (flower honey) > 8(honeydew honey)	> 8 (flower honey) > 8 (honeydew honey)	> 8 (flower honey) > 8 (honeydew honey)
Invert sugar (%)	> 65 (flower honey) >60(honeydew honey)	> 65 (flower honey) > 60 (honeydew honey)	> 65 (flower honey) > 60 (honeydew honey)
Sucrose (%)	< 5 (flower honey) <10(honeydew honey)	< 5 (flower honey) < 10 (honeydew honey)	< 5 (flower honey) < 10 (honeydew honey)

In today's world, where human health comes to the fore, in addition to the quality tests of honey in import and export, contaminated harmful compounds and additives both during the production period and during the harvest and storage period have come to the fore. For example, some pesticides used in plant production and some veterinary drugs used for the health of honey bees (Apis mellifera L.) pose major problems in the consumption and export of bee products, especially honey, all over the world. In this regard, various studies have been carried out in the scientific field and the importance of drug residues has been revealed (Tolon and Wallner, 1999; Sunay et al., 2003; Sabatini et al., 2003; Szerletics Turi and Szalai Matray, 2003; Posyniak et al, 2003).

Acaricides, which are veterinary drugs, are widely used against the Varroa Jacobsoni parasite in honey bee hives. Today, coumaphos (O-3-chloro-4-methyl-2-oxo-2H-chromen-7-yl O,O-diethylphosphorothioate), bromopropylate (isopropyl 4,4′-dibromobenzilate), amitraz [N-methylbis (2, Acaricides such as 4-xylyliminomethyl)amine] and fluvalinate [(RS)-α-cyano-3-phenoxybenzyl N-(2-chloro-α,α,α-trifluoro-p-tolyl)-= -valinate] are still used in different applications around the world. are used in their forms. These acaricides used in the hive can contaminate honey and wax. For this reason, a variety of methods have been developed to determine the residues of these acaricides in honey. Chief among these are the methods developed using GC-MS (Lodesani et all., 1992; Garcia et all., 1996; Jimenez et all., 1997; Volante et all., 1998; Menkissoglu-Spiroudi et all., 2000. Juan José Jiménez et al.,

Within the scope of the maximum residue limits of veterinary drugs in the Turkish Food Codex and the European Union (2001/1/EC), Fluvalinate and Naphtalene should not be present in honey, and Amitraz 200 ppb and Coumaphos 100 ppb must be within the residue limits in honey. Limit values of veterinary drugs other than these include differences in the Turkish Food Codex and the EU. For example, according to the Turkish Food Codex, antibiotics can be tolerated up to certain limits (Sulfamethazine, Tetracycline, 10 ppb, Streptomycin, 20 ppb), while according to the European Union (2001/1/EC), there should be no antibiotic residues in honey. The use of antibiotics against bee diseases is already banned in EU countries.

Table 4: Veterinary drug residue limits determined by standarts.

Veterinary Drugs Maximum residue limits (MRL) µg/kg	Turkish Food Codex (ppb)	European Union (2001/1/EC) (ppb)
Amitraz	200	200
Coumaphos	100	100
Fluvalinate	-	-
Naphtalene	-	-
Sulfamethazin	10	-
Tetracycline	10	-
Streptomycin	20	-

Honey contains mineral substances in varying amounts depending on its plant origin. In addition to the elements given in Table 5, honey contains trace amounts of chromium (Cr), Lithium (Li), Nickel (Ni), Lead (Pb), Tin (Sn), Zinc (Zn), Osmium (Os), Beryllium (Be), There are Vanadium (V), Zirconium (Zr), Silver (Ag), Barium (Ba), Gallium (Ga), Bismuth (Bi), Gold (Au), Germanium (Ge) and Strontium (Sr) elements (Tolon, 1999).).

Table 5: Mineral Substance in Honey.

Componenet	Light colored (ppm)			Dark honeys (ppm)		
	Mean	Min.	Max.	Mean	Min.	Max.
Potassium	205	100	588	1676	115	4750
Sodium	18	6	35	76	9	406
Calcium	49	23	68	51	5	265
Magnesium	19	11	56	35	7	120
Iron	2,40	1,2	4,8	9,4	0,7	33
Copper	0,29	0,14	0,70	0,5	0,3	1
Manganese	0,30	0,17	0,44	4,1	0,5	9
Chlorine	52	23	75	113	48	205

In addition to veterinary medicines and pesticides, the structure of honey can also be contaminated with heavy metals in the same environment. Heavy metal values are high in honey produced especially in environments with heavy traffic and industrial areas (Demirezen and Aksoy, 2005). Heavy metals can be transported from the atmosphere to the hive on the hairs of bees, through pollen, water, nectar or secretion honey. When heavy metals in the environment are examined, many variables such as weather conditions such as rain and wind, production season and botanical origin of the plant should be taken into consideration. Rain and wind are effective by cleaning heavy metals from the atmosphere and contaminating them to other environmental sectors. In spring, nectar flow is higher than in summer and autumn, and therefore pollution is lighter. The effect of botanical origin is explained as flowers with morphologically open floral structures and secretory honey being more exposed to contamination (Porrini et al., 2003). The maximum amounts of heavy metals reported to be present in foods by the FAO-WHO (1989) Unified Food Codex are given in Table 6.

Table 6: Maximum amounts of heavy metals reported by the FAO-WHO (1989).

Heavy metals	Max. limits (ppm)
Cadmium	-
Bullet	0,1-2,0
Copper	0,1-5,0
Iron	1,5-15
Zinc	5
Fe + Cu + Zn	20

7. Conclusion

Since honey is mainly used as a source of nutrients and energy, and is also important for human health, compliance with quality and standards is important. As a result of the rich variety of plants in our country, various honeys of herbal origin such as plateau, citrus and chestnut are produced. Quality honey can be produced by paying attention to quality criteria in honey production. Especially in the process of accession to the European Union, the opportunity to capture this market by producing the product in accordance with quality and reliable standards should be taken advantage of. Considering the fact that the largest honey consumer countries in the world are the member countries of the

European Union and that the beekeeping potential and honey production of these countries do not meet the need, attention should be paid to the production of quality products by being aware of how important this opportunity is.

REFERENCES

Albay, R., 2003. Balın Kristalleşmesi. II. Marmara Arıcılık Kongresi. 28-30 Nisan 2003. Yalova, s: 200-2005

Al Somai, N., Coley, K. E., Molan, P.C., Hancockb, M., 1994.Susceptibility of Heliobacter pylori to the Antibacterial Activity of Manuka Honey. J. Royal Soc. Med. 87: 9-12.

Anonim, 1990. Association of Official Analytical Chemists (AOAC). Methods of Analysis, 15th edition.

Anonim, 2000. Türk Gıda Kodeksi Bal Tebliği. (Tebliğ No : 2000/ 39)

Anonim, 2005. FAO (Food and Agriculture Organisation) http://www.fao.org.

Armon, P.J. 1980. The use of honey in the treatment of infected wounds. Tropical Doctor, 10: 91.

Avcı,M.,2005 Çeşitlilik ve Endemizm açısında Türkiye'nin Bitki Örtüsü.İstanbul Üniversitesi Coğrafya Dergisi, 13, 27-55.

Crane, E., 1975. Honey: A comprehensive survey. Heineman; London, UK; 608 pp.

Demirezen, D., Aksoy, A.: Determination of heavy metals in bee honey using by inductievly coupled plasma optical emission spectrometry (ICP-OES).G.U. Journal of science, 2005, 18(4):569-575.

Dumronglert, E. 1983. A follow-up study of chronic wound healing dressing with pure natural honey. J. Nat. Res. Council, Thailand, 15(2): 39-66

Feraboli, F., 1997. Apıtheropy ın Orthopaedic Diseases. İnternational Coference on: Bee Product: Properties, Applications and ApitherapyP:55. Israel.

Haffejeei, E., Moosa, A., 1985. Honey in the Treatment of Infantile Gastroenteritis. Br. Med. J. 290:1866-1867.

Hutton, D.J. 1996. Treatment of pressure sores. Nursing Times, 18:1533-1534

Jimenez, J.J., Bernal, J.L., Del Nozal, M.J. and Martín, M.T., 2005. Residues of organic contaminants in beeswax. Eur. J. Lipid Sci. Technol., 107: 896–902.

Jimenez, J.J., Bernal, J.L., Del Nozal, M.J., Toribio, L., Atienza, J., 1997. Characterization and monitoring of amitraz degradation products in honey. Journal High Resolut. Chromatogr. 20 :2 p: 81-84.

Garcia, M.A., Fernandez, M.I., Herrero, C. and Melgar, M.J., 1996. Acariside residue determination in honey. Bull. Environ. Contam. Toxicol., 56: 881-887.

Genç, F., 1994. Arıcılığın Temel Esasları. Atatürk Üniv. Ziraat Fak. Ofset Tesisleri, Yay. No: 166, Erzurum.

Grandi, A.; Rossi, J and Bertuccioli, M., 1980. Determination of Chemical, Physical and Microbial Parameters during Storage of Honey. Teah. Alinen, 3(2): 19-26

Gül, A ve Şahinler., N. 2004. Balın Yapısına ve Kalitesine Etki Eden Faktörler," 4.Ulusal Zootekni Bilim Kongresi, 1-3 Eylül, Isparta

Katsilambros, N.L., Philippides, P., Touliatou, A., Georgakopoulos, K.,Kofotzouli, L. Frangaki, D., Siskoudis, P., Marangos, M. andSfikakis, P. 1988. Metabolic effects of honey (alone or combined with other foods) in type II diabetics. Acta Diabetologica Latina, 25 (3): 197-203

Krell .R. 1996. Value-Added Products From Beekeeping. FAO Agricultural Services Bulletin No. 124 Food and Agriculture Organization of the United Nations Rome.

Lodesani, M., Pellacani, A., Bergomi, S., Carpana, E., Rabitti, T., Lasagni, P., 1992. Residue determination for some products used against varroa infestation in bees. Apidologie, 23, 257–272.

Menkissoğlu Spiroudi, U., Diamantidis, G.C., Georgiou, V.E. and Thrasyvoulou, A.T., 2000. Determination of malathion, coumaphos, and fluvalinate residues in honey by gas chromatograpphy with nitrogen-phosphorus or electron capture detectors. J.A.O.A.C. int., 83 (1): 178-182.

Molan, P.C., 1997. Honey as an Antimicrobial Agent. İnternational Coference onBee Product: Properties, Applications and Apitherapy P:27.İsrael.

Postmes, Th. J., Bosch, M. M.C., Dutrieux, R., Van Baare, J., Hoekstra, M.J., 1997 Speeding up the Healing of Burs Wiht Honey İnternational Coference onBee Product: Properties, Applications and Apitherapy P:36. İsrael. 40(8): 912-913

Porrini, C; Sabatini, A.G; Girotti, S; Ghini, S; Medrzycki, P; Grillenzoni, F; Bortolotti, L; Gattavecchia, E; Celli, G., 2003. Honey bees and bee products as monitors of the environmental contamination. Apiacta 38 (2003) 63-70.

Rosenblat, G; Angonnet, S; Gorosit, A; Tabak, M; Neeman, I., 1997. Antioxidant Properties of Honey Produced by Bees fed with Medical Plant Extracts. İnternational Coference on Bee Product: Properties, Applications and Apitherapy P: 49. İsrael

Sabatini, A.G.; Carpan, E.; Serra, G and Colombo, R., 2003. Presence of Acaricides and Antibiotics in Samples of Italian Honey. Apiacta 38 (2003)46-49

Schmidt, J.O.1997.BEE PRODUCT Chemical Composition and Application.İnternational Coference on: Bee Product: Properties, Applications and Apitherapy P:15. İsrael.

Shambough, P., Worthington, V. and Herbert, J.H. 1990. Differential effects of honey, sucrose, and fructose on blood sugar levels. J. Manipul. Physiol. Therapeutics, 13 (6): 322-325

Sönmez, R ve Altan, Ö., 1992, Teknik Arıcılık, Ege Üniversitesi, Ziraat Fakültesi, Ege Üniversitesi, Basımevi Yay. No: 499, Bornova-İZMİR

Sunay, E.A.; Altıparmak, Ö.; Doğaroğlu, M ve Gökçen, J., 2003. Türkiye ve Dünya'da Bal Üretimi, Ticareti ve Karşılaşılan Sorunlar. II. Marmara Arıcılık Kongresi. 28-30 Nisan 2003. Yalova

Szerletics Turi, M and Szalai Matray, E., 2003. Honey and Wax Analysis for Acrinathrin Residues. Apiacta 38 (2003) 34-39.

Şahinler, N.; Ceylan, D.A ve Gül, A., 2003. 1970'li Yıllardan Günümüze Türkiye Arıcılığının Değerlendirilmesi. II. Marmara Arıcılık Kongresi. S:11. 28-30 Nisan.Yalova 11 p

Şahinler, N ve Gül, A., 2004. Yayla ve Ayçiçek Ballarının Biyokimyasal Analizi. 4. Ulusal Zootekni Bilim Kongresi, 01-03 eylül 2004. Isparta

Şahinler, N.; Şahinler, S ve Gül, A., 2004. Biochemical Composition of Honeys Produced in Turkey. Journal of Apicultural Research. 43 (2):53-56.

Şahinler, N., Gül, A., 2005. Effects Of Heating and Storage on Honey Hydroxy Methylfurfural and Diastase Activity," Journal of Food Technology, 3(2), 152-157

Şahinler, N. "Effects Of Heating And Storage On Hydroxy Methylfurfural And Diastase Activity Of Different Turkish Honeys". Journal of Apicultural Research, 46(1):36-41 (2007)

Tolon, B and Wallner, K., 1999. Varroacide use in Turkey and their residues on pine honey. Apimondia'99 36th Congress, 12-17 September, Vancouver, Canada. 267

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